Study and management of an isolated, rare population: the Fresno kangaroo rat

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A case study of the Fresno kangaroo rat may provide a model for management of other small, isolated, and at-risk populations.

The San Joaquin kangaroo rat (*Dipodomys nitratoides*) is a California endemic, historically limited to the San Joaquin and adjacent valleys (Best 1991). There are 3 recognized subspecies: Fresno (*Dipodomys nitratoides exilis*), Tipton (*D. n. nitratoides*), and short-nosed (*D. n. brevinasus*). Land cultivation has had a negative impact on the species as a whole (Chesemore and Rhodehamel 1992, Williams and Germano 1992), and the Fresno and Tipton kangaroo rats are now listed as endangered at the federal and state levels. In particular, cultivation of agricultural land has resulted in many small and isolated populations of San Joaquin kangaroo rats (Chesemore and Rhodehamel 1992); the Fresno kangaroo rat population at Naval Air Station (NAS) Lemoore is one such population.

The species as a whole occupies arid, often alkaline, plains sparsely covered with grasses and some saltbrush (*Atriplex* spp.). They are often associated with slightly raised strips of hummocks. Burrows are usually at the base of a low bush, and runways, worn in grass, often lead from the burrow to adjoining clumps of vegetation. Burrow systems are on elevated soil and may occupy an area 2-3 m wide (Best 1991, Chesemore and Rhodehamel 1992).

At NAS Lemoore, Fresno kangaroo rats are limited to the Tumbleweed Park wildlife area, encompassing about 40 ha and surrounded by land in cultivation. No other populations were found during base-wide surveys from August 1992 to May 1993 (Kuenzi and Morrison, Univ. Arizona, Tucson, unpubl. data). The history of kangaroo rats on the wildlife area is largely unknown. A motor-cross track consisting of dirt tracks of various widths winds through the site. In early March 1992, unauthorized attempts to widen the track using a tractor damaged kangaroo rat burrows. A damage assessment found that 64% of the area occupied by kangaroo rats had been damaged. The motor-cross track was subsequently closed to public access. Naval personnel recognized the need for close consideration of population viability of kangaroo rats in this area.

Management of rare, isolated populations

Population viability of a single isolated population such as the one at Lemoore depends on the interaction of several factors (Gilpin and Soulé 1986, Shaffer 1987, Lande 1988). Perhaps most important are deterministic factors, such as continued habitat loss or site modification from activities on or at the edge of the site. Stochastic factors also need to be considered because they are not predictable at a given time; these include demographic, environmental, and genetic uncertainty. The minimum information required to project viability under demographic uncer-

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tainty is population size and demographic vital rates (i.e., age-specific survival and fecundity).

We were presented with a management mandate by the United States Navy to determine the best possible means of enhancing a population that was already extremely rare and do so within a short time and at a minimal cost. Our work may serve as a case study for development of a management plan for recovery of an isolated and extremely rare population. We used empirical data to explore factors affecting viability of the Fresno kangaroo rat at NAS Lemoore. Some variables such as fecundity, variance in vital rates, and inbreeding costs could only be estimated from studies implemented over larger spatial and temporal scales than were possible in our study. Thus, our fieldwork was limited to examining density of kangaroo rats over different vegetation types on the site. Our work led to management recommendations to improve the status of the population at NAS Lemoore.

Field sampling

The Lemoore kangaroo rat area (KRA) has virtually no alkali depressions or naturally bare areas. Most of the site is thickly covered with vegetation; clearings as of January 1993 were limited to roads and bare areas created by motor-cross racing. The central, heavily-used portion of the racetrack consisted of approximately 5-6 ha of mostly bare ground. To assess differences in the number of kangaroo rats between the exposed areas and the grass areas, we established 2 permanently marked trapping grids. The exposed grid was rectangular to encompass the center of the racetrack area. The grid included 7 rows of 12 traps each, a total of 84 traps, with 15-m spacing between traps (grid size = 1.9 ha). The grass grid was identical in shape and size, and we placed it about 150 m away in an area of relatively homogeneous vegetation.

On each of the 2 trapping grids we used equal numbers of 2 sizes of Sherman livetraps, with a given trap type at every other station: extra-large (10.2 x 11.5 x 38.4 cm) and large (7.7 x 9.0 x 23.0 cm). Each trapping session involved 3-5 nights of trapping. We set traps baited with bird seed and with a paper towel for insulation 30-90 minutes before sunset. To capture kangaroo rats during the primary period of activity (Lockard and Owings 1974) while minimizing mortality risk, we checked and closed traps 4-6 hours after sunset. We checked both trapping grids simultaneously. Captured kangaroo rats were weighed, sexed, measured (hind foot and total length), and marked with individual ear tags; recaptured animals were identified by ear tag, weighed, and released at the capture location.

In designing mark-recapture sampling, we followed the robust design described by Pollock (1982) and Pollock et al. (1990). The design relies on k primary sampling periods (i.e., monthly sampling), with each primary period made up of j secondary sampling sessions (i.e., nightly sessions within each month); the number of secondary sessions need not be equal in all the primary periods. With this approach, population size could be estimated each month (primary period) using closed-population models that allowed for varying degrees of unequal catchability (i.e., Lincoln-Petersen index and estimators in Program CAPTURE; see White et al. 1982). Also, the robust design can, in principle, provide estimates for age-specific survivorship and fecundity by pooling capture data within secondary periods and analyzing across primary periods.

Preliminary trapping conducted in December 1992 indicated relatively high capture probabilities and population densities for kangaroo rats in the exposed portion of the KRA. These data, when incorporated into power analysis graphs (Pollock et al. 1990), indicated that a sufficient sample would be 5 primary-sampling periods with up to 5 secondary-periods (trapping nights) in each primary period. Thus, we attempted to trap for 5 nights in the middle of each month from January through May 1993.

Interpretation and discussion

We trapped kangaroo rats in the KRA for 3-5 nights/month from January through May 1993 for a total of 3,690 trap nights. No kangaroo rats were observed between the grass and exposed grids. We captured kangaroo rats in the grass grid in January, leading to a Lincoln-Petersen estimate of 7 (95% CI = 7-10) for the grid. In the following 3 months fewer animals were captured: 5, 0, 0. We did not trap in the grass grid in May. Population estimates for the exposed grid in January ranged from 44 to 97, with most estimators in the range of about 50. The densities on the exposed grid in January were at the upper end of densities found for both San Joaquin (Williams and Germano 1992) and Merriam's (*D. merriami*; McClenaghan 1984, Zeng and Brown 1987) kangaroo rats.

In later months (except for March) inclement weather and declining numbers of captures prevented calculation of population size estimators using program CAPTURE, but the Lincoln-Petersen estimator indicated a strong decline in numbers, from about 26 animals in February to 8-9 animals in April and May. The decline did not appear to be caused by a negative trap response of captured animals, as recapture probability was higher than initial capture probability (P) for both months in which data were sufficient to make the calculations (e.g., in January: capture $P = 0.11$ and recapture $P = 0.55$).

Concurrent with the decline in kangaroo rat abundance on the exposed grid was an aggressive bloom of vegetation throughout the site. In particular, 2 species of barley (*Hordeum* spp.) and 3 species of brome (*Bromus* spp.) covered the exposed grid, so that its appearance resembled that of the grass grid. All 5 invading species were non-native to California (Hickman 1993): foxtail chess (*Bromus madritensis*), ripgut grass (*B. diandrus*), soft brome (*B. hordeaceous*), Mediterranean barley (*Hordeum marinum*), and farmer's foxtail (*H. murinum*).

The low densities of kangaroo rats on the grass grid throughout the study and the declining number of captures on the other grid as it changed from exposed to grassy suggested that thick vegetation may be a cause of declining kangaroo rat densities on the KRA. Other studies have shown that San Joaquin kangaroo rats avoid grassy areas (e.g., Culbertson 1946, Hawbecker 1951, Williams and Germano 1992). It is possible that densities were similar in the grassy and open areas but that capture probability declined because of obstructions to the animals' movements; however, the lack of active burrows or apparent runways (A. J. Kuenzi, Univ. Arizona, Tuscon, pers. observ.) in the grassy areas argues against this explanation. We did not see signs of dispersal off the site as the number of animals captured declined on the site, but we cannot exclude the possibility that animals emigrated.

The small numbers of captures did not allow us to calculate demographic rates such as survival or fecundity (Pollock et al. 1990). We did, however, use the mark–recapture data to estimate densities on the KRA. Dividing the population size estimate by the area trapped gave a density estimate that was biased high because some animals whose home ranges were outside the area were probably trapped and counted as occupying the grid (White et al. 1982). As an optimistic estimate of density, we used these overestimates, knowing that the population was probably smaller than we calculated.

In January there was approximately 6 ha of exposed ground in or around the main racetrack, and another 1 ha in abandoned roads and tracks elsewhere on the KRA. Using the estimates for January from our approximately 2-ha grids, we calculated the following: exposed area on KRA (7 ha x 25 animals/ha) = 175 animals; grass area on KRA (33 ha x 3.5 animals/ha) = 115 animals; total abundance estimate on KRA = 290 animals. We caution that there is potential for considerable error around each of the estimates used in this extrapolation, so no great weight should be put on the point estimate of 290, but an estimate of 300 would be likely for January.

In May, when kangaroo rat habitat was invaded by vegetation, densities were considerably lower. No animals were captured on the grass grid in the previous 2 months, and on the formerly exposed grid numbers of animals captured had dropped to about 11/grid, or about 5.5/ha. We are reluctant to assign "0" as a density in the grass habitat, but clearly densities were low. A first approximation might be: exposed area on KRA (7 ha x 5.5 animals/ha) = 38.5 animals; grass area on KRA (33 ha x 1 animal/ha) = 33 animals. In short, the number of kangaroo rats on the KRA was about 75.

Implications

The Lemoore KRA will probably not support, even in the short-term, a viable kangaroo rat population. When the population density was high, the size of the population of kangaroo rats on the site was only about 300, suggesting a high probability of extinction.

Active management on the site could increase the population size and therefore the probability of persistence of the population, although long-term viability is not certain. In the year of this study we observed a substantial population decline. Seasonal fluctuations in mortality and fecundity of San Joaquin kangaroo rats (D. F. Williams, Calif. State Univ., Stanislaus; and B. Peyton, Univ. Calif., Berkeley, pers. commun.) and other species of kangaroo rat (Price and Kelly 1994) may be caused by precipitation. There is, however, a strong indication that in our study invasion of vegetation, particularly non-native grasses, exacerbated declines: (1) our grass grid captured few animals during the entire study; (2) the decline in numbers on the exposed grid corresponded with vegetation growth on the grid; and (3) a road that remained exposed maintained relatively high numbers of kangaroo rats (Morrison, Calif. State Univ., Sacramento, unpubl. data). This species of kangaroo rat has historically occupied sites that were heterogeneous, with open areas available (Best 1991, Chesemore and Rhodehamel 1992). By contrast, the Lemoore KRA is small and apparently susceptible to becoming a homogeneous vegetated patch, unsuitable for kangaroo rats. Therefore, active management to maintain some exposed ground on the KRA is vital.

Although active management of existing habitat may increase the population size of the kangaroo rats on the KRA, substantial increases can only be achieved by increasing the amount of suitable habitat. Culbertson (1946) noted that Fresno kangaroo rats reinvaded fields that were no longer cultivated; therefore a kangaroo rat set-aside of agricultural land may not require intensive site preparation.

At least 1 additional population should be established near, but not adjacent to, the KRA. New populations might exhibit independent dynamics in regard to extinction threats (Hanski and Gilpin 1991, Doak and Mills 1994). For example, 2 separated populations are, collectively, less likely to be extinguished by a predator or disease. To the extent that separate populations exhibit uncorrelated environmental variation, there would be less probability that an environmental impact would negatively affect all individuals in both populations. Furthermore, extinction in 1 population could be followed by recolonization from another (e.g., the "rescue effect"; Brown and Kodric-Brown 1977). Simulation models are useful for elucidating costs and benefits of varying the number of populations (Burgman et al. 1993).

Multiple populations may also minimize inbreeding depression. Even moderate inbreeding can substantially increase the probability of extinction. However, genetic variation in a population can be maintained and inbreeding depression can be prevented, with quite small levels of gene flow (Levin 1988).

In summary, any population of kangaroo rats added to the Lemoore KRA needs to be far enough away so that it will have independent population dynamics and genetic structure, but close enough to insure exchange of individuals. Jones (1989) found the upper limit for lifetime dispersal distances of Merriam's kangaroo rat to be 265 m for males and 158 m for females (Zeng and Brown 1987). B. Peyton (Univ. California, Berkeley, unpubl. data) found that short-nosed kangaroo rats moved ≥400 m during dispersal. However, Daly et al. (1990) demonstrated that more mobile Merriam's kangaroo rats were more susceptible to predation. We suggest that populations be separated by habitat suitable for kangaroo rat travel and a distance of approximately 300-500 m. The small and isolated population of kangaroo rats at NAS Lemoore does not allow for collection of more detailed data prior to initiating management actions. The response of kangaroo rats on the NAS should be closely monitored and appropriate changes made in population models and management plans as necessary.

The impacts of land cultivation and habitat fragmentation on Fresno kangaroo rats are symptomatic to those impacting other taxa worldwide (Clark et al. 1990, 1994). Our study design and subsequent management plans are applicable to other species being influenced by agricultural and urban developments (e.g., see Backhouse et al. [1994] for a study of the Australian eastern barred bandicoot [*Perameles gunnii*]).

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