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Translocating endangered kangaroo rats in the San Joaquin Valley of California: recommendations for future efforts

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Since the early 1990s, translocation has been advocated as a means of mitigating impacts to endangered kangaroo rats from development activities in the San Joaquin Valley. The factors affecting translocation are numerous and complex, and failure rates are high. Based on work we have done primarily with Tipton kangaroo rats and on published information on translocations and reintroductions, we provide recommendations for future translocations or reintroductions of kangaroo rats. If the recommended criteria we offer cannot be satisfied, we advocate that translocations not be attempted. Translocation under less than optimal conditions significantly reduces the probability of success and also raises ethical questions.

Key words: *Dipodomys heermanni*, *Dipodomys ingens*, *Dipodomys nitratoides*, reintroduction, San Joaquin Valley, Tipton kangaroo rat, translocation

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Largely due to habitat loss, several species or subspecies of kangaroo rats (*Dipodomys* spp.) endemic to the San Joaquin Valley of California have been listed by the state and federal governments as endangered. These include the giant kangaroo rat (*D. ingens*), and two subspecies of the San Joaquin kangaroo rat (*D. nitratoides)*, both of which occur in the San Joaquin Desert portion of the valley (Germano et al. 2011) and currently persist on only 2–4% of their historic ranges (Williams and Germano 1992). Despite federal and state protections, projects that eliminate occupied habitat continue to be approved. The giant kangaroo rat and the Tipton kangaroo rat (*D. n. nitratoides)*, which is one of three currently recognized subspecies of *D. nitratoides,* have largely been the focus of translocation efforts since the early 1990s because of their protected status. Translocation of these species, as well as other endangered species, has often been proposed by resource

agencies as a strategy to save individuals that are impacted by land development activities (O'Farrell 1999, Germano 2001, Edgar et al. 2005, Ashton and Burke 2007, Germano 2010, Germano et al. 2013).

Aside from land development activities, translocation or reintroduction are also conservation strategies for restoring or expanding extirpated populations, and the number of translocations or reintroductions completed annually has grown in the last two decades (Griffith et al. 1989, Wolf et al. 1996, Fischer and Lindenmayer 2000, Morrison 2009, Perez et al. 2012). In some cases, translocation or reintroduction has been successful. For example, successful reintroduction of the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*) to a portion of its range from which it had been extirpated likely reduced its risk of extinction (Holler et al. 1989). Also, in southern California, the Stephens' kangaroo rat (*Dipodomys stephensi*) was successfully reintroduced to a portion of its range (Shier and Swaisgood 2012). However, in most cases where translocation has been attempted, the outcome either has been unsuccessful or has not been determined (Fischer and Lindenmayer 2000, Armstrong and Seddon 2008). Most translocations have serious design flaws, lack clear necessity, and fail to address basic criteria for translocations established by leading conservation groups, such as the International Union for Conservation of Nature (IUCN; Perez et al. 2012).

Based on work we have done primarily with Tipton kangaroo rats since the early 1990s, and published information on translocations and reintroductions, we provide recommendations for future translocations or reintroductions of Tipton kangaroo rats. These recommendations, with some modifications, also should apply to translocating giant kangaroo rats and other kangaroo rat species in the western United States. We use standard definitions of the IUCN to define the terms translocation and reintroduction. We recognize that there are other definitions, such as introduction, reintroduction, and augmentation, which are widely used in restoration ecology (e.g., Falk et al. 2006, Mills 2007, Morrison 2009); however, we have chosen to follow IUCN definitions in this manuscript. Thus, translocation is the human-mediated movement of wild animals from one part of their range to another, and reintroduction is the movement of individuals to areas within their historic range from which they have been extirpated (IUCN 1998). Our recommendations apply to either situation. We also use conventional criteria for determining success: a translocation or reintroduction is successful if the introduced population is self-sustaining (i.e., there is successful reproduction of progeny; Griffith et al. 1989).

We make these recommendations because no formal set of guidelines has been established by the agencies that are responsible for the recovery of Tipton kangaroo rats — or any other species of kangaroo rat. Typically, if a translocation is deemed necessary in order to salvage kangaroo rats, biologists are not given enough time to implement one or more of the criteria that will improve translocation success. Although based largely on our own experiences, we provide these recommendations for consideration in any management decisions or permits required to translocate kangaroo rats. Our goal is that these recommendations will be factored in well before animals are moved in the San Joaquin Valley or, potentially, in other parts of California.

Recommendations

Absence of Tipton kangaroo rats on the translocation site.—One of the first considerations when choosing a translocation site is to ensure that Tipton kangaroo rats do not currently occupy the site. Because so few sites in the San Joaquin Valley support this subspecies, the first priority should be to protect any site where they are found. While long-term conservation strategies may suggest that moving small, isolated populations to larger, more protected sites will reduce the chances of genetic depression in small populations (e.g., bottlenecks, genetic drift, etc.) and better their changes of long term survival, we suggest that, currently, it is more important to identify and protect any site that is occupied by the Tipton kangaroo rat. Furthermore, we have seen Tipton kangaroo rats survive and, in fact, thrive on small patches of isolated habitat. Before considering any movement between or among populations, it is important to identify as many existing populations as possible, and then determine an appropriate long-term strategy that incorporates objectives for preserving genetic diversity.

Another reason that a translocation site selected should not have extant Tipton kangaroo rats is that kangaroo rats have intricate intraspecific social relationships and it would be difficult to introduce new individuals into an existing population without inciting agonistic behaviors by residents (Tennant 2011, Shier and Swaisgood 2012). It is likely many individuals translocated to an already occupied site will not survive. Even when translocated animals survive, they may displace resident animals, resulting in losses equivalent to the addition of individuals, especially if the resident population is at or near carrying capacity. In either case, no net benefit to the species is likely.

Absence of congeneric competitors.—In previous studies, translocations into areas with a congeneric competitor were less successful than translocations to sites without a resident, or even a potential, competitor (Griffith et al. 1989). For heteromyids, decades of research has demonstrated that competition plays a strong force in community structure and that sympatric desert rodents partition both biotic and abiotic environmental factors due to interference competition (see reviews by Brown and Harney 1993, Randall 1993). Typically, larger heteromyids use aggressive interference to outcompete smaller species (Blaustein and Risser 1976, Frye 1983, Basset 1995, Perri and Randall 1999; but, see Bleich and Price 1996). In the San Joaquin Valley, an exclusion experiment demonstrated that the larger Heermann's kangaroo rat (*D. heermanni*), which typically occurs sympatrically with Tipton kangaroo rats, can competitively depress populations of the smaller Tipton kangaroo rat through interference competition (Tennant and Germano *in press*).

Thus, we recommend that translocation efforts for Tipton kangaroo rats consider the potential competitive effects of larger, coexisting congeners. In order to mitigate the effects of competition, we suggest that it may be necessary to remove competing species. Since giant kangaroo rats are the largest kangaroo rat (Williams et al. 1993a), less concern about competitors is necessary during translocations because this species is behaviorally dominant over smaller kangaroo rats (author's personal observations; also see Blaustein and Risser 1976, Frye 1983, Basset 1995, Perri and Randall 1999).

Since the early 1990s, site selection for translocation and reintroduction of Tipton kangaroo rats has been based on the presence or absence of congeneric competitors. However, as is often the case with small mammal communities, populations fluctuate

temporally. Thus, despite choosing sites apparently devoid of competitors, competitors may, indeed, be present. This was the case in a 2006 translocation of Tipton kangaroo rats to the Allensworth Ecological Reserve, Tulare County (35° 50' 26.4" N, 119° 20' 26.2" W) where trapping three months before the translocation documented only one Heermann's kangaroo rat, but subsequent monitoring eight months after the translocation showed that numbers of Heermann's kangaroo rats had increased dramatically (Germano et al. 2013) and were excluding Tipton kangaroo rats through interference competition (Tennant and Germano *in press*).

We recommend walking reconnaissance surveys over the entire target translocation site and trapping in areas with burrow systems present to assess species presence or abundance. Thus, we suggest that trapping need not occur over the entirety of the site, but should at least be conducted in portions of the target area where kangaroo rat burrows are located. We recommend that these surveys occur no earlier than one month prior to the translocation date. As an example, two initial trapping surveys during a Tipton kangaroo rat reintroduction effort to Kern National Wildlife Refuge, Kern County, (35° 45' 36.1" N, 119° 34' 50.7" W) indicated that Heermann's kangaroo rat abundance was low (B. Cypher, unpublished data). However, the reintroduction was delayed by almost a year due to inclement weather, site inaccessibility, and other factors. During that time, Heermann's kangaroo rat numbers increased markedly, and likely contributed to the apparent failure of this reintroduction effort (B. Cypher, unpublished data).

Ideal translocation sites are those devoid of congeneric competitors. However, it is extremely difficult to find sites in the San Joaquin Valley that have both suitable habitat and are devoid of either the target species or competitors. We recommend that if more than two individual competitors are captured over a 200 trap-night census, then the population of competitors may be too high. Depending on the size and density of the areas with active burrows, we recommend a minimum 50 traps should be set in areas with kangaroo rat sign. The traps can be set in a grid formation or at active burrow locations. We recommend trapping over at least a four-night census period (equating to a minimum of 200 trap-nights).

If translocation sites for Tipton kangaroo rats cannot be found that have both appropriate habitat and a low number of congeneric competitors, we suggest that competitors be removed before translocating Tipton kangaroo rats. Even if a few competitors remain on site (it is unlikely that trapping will totally eliminate the competitors), the translocated species will have a better chance of becoming established. Additionally, continued trapping to remove congeneric competitors even after the translocation has been completed may be warranted. For example, during a competitor removal study in 2009 at Allensworth Ecological Reserve, Heermann's kangaroo rats were continually removed from the study site over the course of the study period (Tennant and Germano *in press*). Furthermore, patterns of day burrow use suggest that kangaroo rats may prefer to avoid the home ranges of other kangaroo rat species (Perri and Randall 1999). Thus, it is possible that once a Tipton kangaroo rat population is established on a site, abundance and spacing mechanisms may allow them to better compete and coexist with congeneric competitors.

Intraspecific relationships and spacing.—Kangaroo rats have complex neighbor relationships that may help to reduce aggression among conspecifics because of familiarity and relatedness between neighbors (Randall 1989, 1991, 1993). Thus, attention should be given to spacing and neighbor relationships to reduce intraspecific aggression and mortality during translocations. Other translocation research has demonstrated that attention to familial

relationships can increase survivorship. For example, research on prairie dogs has shown that keeping familial relationships intact decreases stress and increases survivorship (Shier 2006). Survivorship of translocated Stephens' kangaroo rats (*D. stephensi*) was greatly increased when neighbor relationships where kept intact (Shier and Swaisgood 2012).

We suggest that translocations take into account neighbor relationships on donor sites. Based on our experience, one way to do this is to group individuals on the recipient site in the same spatial arrangement that they were trapped at the source location. Thus, kangaroo rats trapped in adjacent traps on the donor site will be placed in adjacent burrows on the recipient site. This requires advance planning using spatial maps of both the donor and recipient sites so that individuals can be grouped together.

In spacing kangaroo rats on the recipient site, we have generally tried to place individuals close enough so that they will come into contact and find mates, but also far enough apart so as to avoid aggressive interactions. In past translocation efforts, kangaroo rat burrows and cages have been spaced at least 15 m apart. However, Tipton kangaroo rats tend to have larger home ranges than other kangaroo rat species (ca. 1000–3000 m^2; Tennant and Germano *in press*); thus, 15-m spacing may be too close and may promote aggression. More research is needed on kangaroo rat burrow spacing dynamics so that translocations can better incorporate proper spacing parameters. One possible option is to map the burrow locations of each individual at the source location through trapping and night vision technology, and then emulate this spacing on the recipient site (D. Shier, University of California, Los Angeles, personal communication).

Time of year.—We recommend that translocations of kangaroo rats generally be avoided during high or low temperature extremes, or other ambient conditions that would cause excessive stress to individuals. However, because many translocations occur within project development timelines, avoiding temperature extremes often is difficult. For example, a 2006 translocation of Tipton kangaroo rats to Allensworth Ecological Reserve occurred at the beginning of December when low temperatures were barely above freezing because development at the source location was slated to begin (Germano et al. 2013).

Other studies involving translocated dormice (*Muscardinus avellanarius)* found that animals released in early summer (May, June) lost more body mass than those released in late summer (August, September; Bright and Morris 1994). Bright and Morris (1994) also suggested that food scarcity for dormice in early summer may necessitate supplemental feeding. It is unknown to what extent seasonal food shortages affect kangaroo rat populations and how this should be factored into translocation efforts. Food availability may be highest in the late spring, just after annual herbaceous vegetation has matured. Food shortages and population pressure do impact kangaroo rat populations in extreme drought years (Williams et al. 1993b); thus, we suggest that no translocations occur during drought years.

Avoiding the prime reproductive period of kangaroo rats is another factor that is important to consider in translocation efforts. Kangaroo rats primarily breed from February until fall, depending on food availability and other environmental factors (Tappe 1941, Fitch 1948, Eisenberg and Isaac 1963, Jameson and Peeters 1988). Removing endangered kangaroo rats from a source population during the breeding or rearing period may disrupt reproductive success, and also impact the source population. For example, a 2010 reintroduction of Tipton kangaroo rats to an area of Kern National Wildlife Refuge likely failed in part because of the active reproductive status of Tipton kangaroo rats at the source site in late August. Because adult females were still lactating or were pregnant at

the source site, we removed and translocated very few adult females in order to lessen the impact to the source population. The majority of the individuals translocated were either adult males or pre-reproductive younger females, and this likely contributed to a failed reintroduction effort (B. Cypher, unpublished data).

Another factor to consider when translocating kangaroo rats is the activity cycles of predators. In the 2010 reintroduction effort to Kern National Wildlife Refuge that took place in late August, northern Pacific rattlesnakes (*Crotalus oreganus oreganus*) killed three reintroduced kangaroo rats (B. Cypher, unpublished data). Several species of snakes are predators of kangaroo rats and, like most reptiles, are active from late spring to early fall. Several species of owls also are predators of kangaroo rats (Grinnell 1932, Hawbecker 1945, Schwartz and Bleich 1985) and, in nearly all translocation efforts we have been involved with, several of the translocated individuals have been preyed upon by owls (Germano 2001, 2010; Germano et al. 2013; Tennant and Germano *in press*). Owls have higher energy requirements during the breeding season when they are rearing young and may take more (or, at least, higher calorie) prey during the spring (Ward et al. 1998). Because high mortality rates are already common when translocating prey species (Germano 2001, Banks et al. 2002, Watland et al. 2007, Germano 2010, Hamilton et al. 2010), we recommend conducting translocations outside of the owl breeding season and when reptile activity is low to reduce the potential for predation.

Given all of these timing factors, we suggest translocations of kangaroo rats in the San Joaquin Valley should be limited to either fall (late September – November) or early spring (March – April), if kangaroo rats do not show signs of being reproductively active or tending young (lactating). During these times, temperatures are moderate, snake activity is usually low, and other avian and mammalian predators are not breeding.

Habitat quality and burrow refugia.—In a review of translocations by Griffith et al. (1989), successful translocations occurred at sites with both high quality habitat and the presence of refugia (which, for kangaroo rats, would be presence of available burrows in which refuge is taken). In fact, without high quality habitat and assurance that active management will occur on the translocation site, there is a low chance of success no matter how many individuals are released (Griffith et al. 1989; Wolf et al. 1996). In the San Joaquin Valley, sites with high quality habitat typically are those that lack dense, non-native grass cover, or that are aggressively managed to reduce dense, non-native grass cover that occurs during years when herbaceous growth is high (Germano et al. 2001, 2012). Dense herbaceous cover negatively affects both Tipton kangaroo rats (Figure 1) and giant kangaroo rats (Figure 2). If sites are not managed for low herbaceous cover, the likelihood of continued survival of translocated kangaroo rats is low. Thus, we recommend that any potential translocation site have a vegetation management and monitoring plan in order to ensure active management continues on the translocation site.

The site to which animals are to be translocated should also have accessible burrows, either in the form of abandoned natural burrows suitable for kangaroo rats, or artificial burrows. In a 2009 translocation of Heermann's kangaroo rats, high survivorship (16.3% at 6 months post-release) was documented on a site with a high abundance of available natural burrows in which individuals could take refuge, which appears to be an important factor for survival of translocated kangaroo rats (Tennant 2011). Studies of translocated prairie dogs (*Cynomys* spp.) in Utah also have shown that at sites where there are pre-existing burrow systems, prairie dogs disperse shorter distances and have higher survival rates than in areas

without abandoned burrows (Robinette et al. 1995, Truett et al. 2001). Thus, we recommend that sites with high quality habitat and existing burrows be given higher priority than sites without burrows. If sites do not include ample burrows, artificial burrows should be added (see Germano 2001, Germano et al. 2013), although the extent to which kangaroo rats will use permanent artificial burrows if natural burrows are not available is unknown. The presence and use of artificial burrows may, however, provide enough time for translocated individuals to construct their own burrow systems. Research is needed on the best material for artificial burrows that would provide the temperature and humidity regimes most similar to natural burrows.

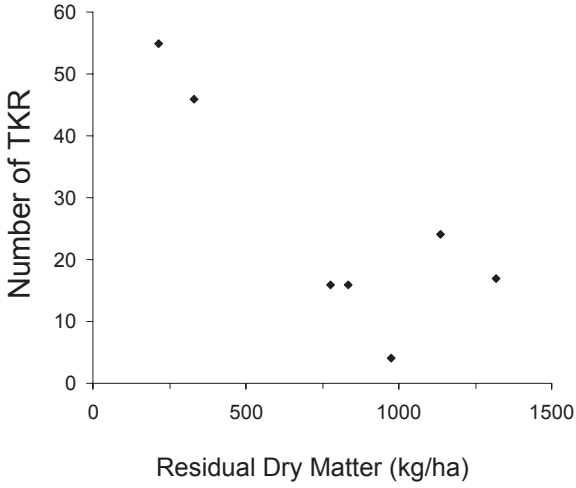

Figure 1.—Correlation between the number of Tipton kangaroo rats (TKR) caught during six-day trapping sessions in the spring and the mean amount of residual dry matter (kg/ha) measured at the Buttonwillow Preserve in Kern County, California. The correlation is significantly negative.

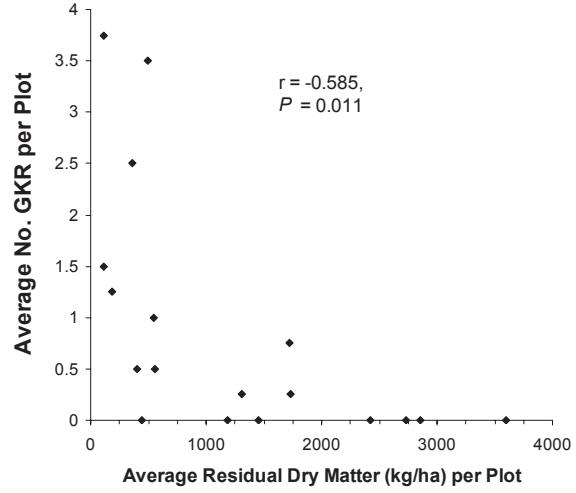

Figure 2.—Correlation between the average number of giant kangaroo rats (GKR) caught during six-day trapping sessions in August on grazed and ungrazed plots and the mean amount of residual dry matter (kg/ha) measured over nine years in Kern County, California. The correlation is significantly negative.

Number of translocated individuals.—Size of translocation and reintroduction efforts for endangered kangaroo rats have ranged from small (15 individuals [Germano 2001, O'Farrell 1999]) to large-scale removals from an entire parcel of occupied habitat (144 individuals [Germano et al. 2013]; 599 individuals [O'Farrell unpublished report {cited in Shier and Swaisgood 2012}]). Also, all past translocation efforts for kangaroo rats have consisted of only one release effort. In an assessment of successful translocations by Griffith et al. (1989), a typical translocation consisted of six releases over a three-year period. Of these releases, the majority consisted of 75 or fewer animals per release (Griffith et al. 1989). Both Griffith et al. (1989) and Fisher and Lindenmayer (2000) reported that success increases when a greater number of animals are initially released. Specifically, Fisher and Lindenmayer (2000) reported that releasing >100 individuals was associated with greater translocation success. Releasing a large number of animals, especially of prey species, serves to satiate predators and provide a buffer effect so that a core population will establish on the site.

Often in the San Joaquin Valley, development projects occur on a small footprint (e.g., oil wells or well pads, small developments <4 ha) and the number of individuals requiring translocation is small (<30 individuals). Since predation rates on translocated prey species is typically high (Germano 2001, Banks et al. 2002, Watland et al. 2007, Germano 2010, Hamilton et al. 2010) and, therefore, overall survivorship typically is low (8.3% [D. Germano and L. Saslaw unpublished data]; 16.3% [Tennant 2011]; both at six months post translocation), we recommend that translocation efforts not be conducted for kangaroo rats if there are <30 individuals to be translocated. Thus, translocations should be conducted with a founder population of at least 30 individuals. Another reason for this recommendation is that small founder populations are prone to a range of genetic problems, such as inbreeding, bottlenecks and genetic drift (Falk et al. 2006, Morrison 2009).

If there are situations with <30 individuals, we recommend alternatives to translocation be investigated. If a project site is small and habitat is available outside of the project area, one possible solution is to erect exclusion fencing around the project area and move animals outside of the project footprint. However, it is still necessary to address potential interspecific and intraspecific conflicts before any movement of animals occurs. Other alternatives could include using animals for research (e.g. captive breeding or behavioral studies) or in outreach opportunities.

Hard or soft releases.—There are two general types of release methods that are used in faunal translocations: a "hard" release and a "soft" release. A soft release involves a period of confinement in an enclosure on the release site that allows animals to become acclimated (Scott and Carpenter 1987, Thompson et al. 2001, Morrison 2002). Typically, all necessary resources (e.g., food and water) are provided during the acclimation period. A hard release is an immediate and direct release of the animal onto the translocation site.

For kangaroo rat translocations, both hard and soft release methods have been used. In both release scenarios, animals typically are placed into either an artificial burrow constructed of man-made materials, such as cardboard or corrugated pipe, or a rudimentary hole augured into the soil (see Germano [2001] and Germano et al. [2013] for detailed methods). Food is provided inside the burrow in both hard and soft releases. In a hard release, animals are placed into an artificial burrow that is lightly plugged with a piece of paper towel. During a soft release, enclosures are placed around the artificial burrow.

Enclosures have been constructed of hardware cloth and the bottom edge of the hardware cloth is buried to a depth of 20-30 cm to prevent animals from quickly digging out. The enclosures also have hardware cloth or netting as a cover to prevent kangaroo rats from climbing out or prevent other animals from entering. After an acclimation period of several days to a month, the enclosures are removed or openings are created in order for animals to leave the confined area.

The assessments by Griffith et al. (1989) and Wolf et al. (1996) found no consistent association between successful translocations and either hard or soft release methods. In the San Joaquin Valley, results from translocation efforts for Tipton kangaroo rats since the 1990s have shown that mortality from predation for hard-released individuals occurs within the first four to five days (Germano 2001, 2010; Germano et al. 2013). For example, in 2001 four Tipton and seven Heermann's kangaroo rats were removed from a project site, fitted with radio-transmitters to monitor survival, and translocated using a hard release. Only one Heermann's kangaroo rat survived to the end of the study (45 days; Germano 2010). Soft release methods potentially could reduce initial high predation rates. In a 2006 translocation study of Tipton kangaroo rats, more soft-released individuals survived than those that were hard-released, but the differences were not significant (Germano et al. 2013). The reverse was true for a study of translocated Heermann's kangaroo rats, but differences in survivorship again were not significant (Tennant 2011). Additionally, in the Heermann's kangaroo rat study, many of the animals dug out of their cages in one to two days, which made it difficult to assess whether caging increased survivorship. Shier and Swaisgood (2012) successfully translocated Stephens' kangaroo rats using a combination of soft-release methods and maintaining the spatial relationships and, presumably, the social structure of animals from the source location.

Many reintroduction studies have shown success with some form of soft release, especially with avian species, which can easily disperse (Gatti 1981, Ellis et al. 2000, Wanless et al. 2002, Mitchell et al. 2011). Successful use of soft release methods has also been beneficial for some small mammals (Holler et al. 1989, Bright and Morris 1994). However, other reintroduction experiments using soft releases have not improved survival, site fidelity, or body condition (Hardman and Moro 2006). In one study with the marsupial rat-kangaroo (*Bettongia lesueur)*, soft-released individuals injured themselves on fencing and that method was terminated (Short et al. 1992, Christensen and Burrows 1995). It may be that cages are another novel environment that increases chronic stress among reintroduced individuals (Teixeira et al. 2007, Dickens et al. 2010), thereby affecting acclimation to the reintroduction site and survival.

Pending further data on the success of hard and soft release methods, we recommend that decisions be based largely on translocation site conditions. If conditions on the chosen site include high quality habitat, ample burrows, and low levels of competitors, then soft releases, especially the use of cages, may not be necessary to increase survival and site fidelity. Performing soft releases requires substantially more effort and resources, and it may not be worth spending limited resources on such efforts if survival is not significantly improved (also see Hardman and Moro 2006). However, additional testing of the benefits and different parameters that may affect survival of individuals of soft releases, such as length of caging time, size of cage, and spacing of cages, should continue.

Monitoring.—Clear goals and criteria for success or failure and monitoring of translocation outcomes are an integral part of any translocation program. However, most translocations have lacked extensive monitoring and standard criteria for success or failure

(Fisher and Lindenmayer 2000, Armstrong and Seddon 2008, Perez et al. 2012). In the majority of translocations we have been involved with, monitoring of translocation success has been extremely limited. In fact, in only one translocation effort has monitoring extended beyond six months (Germano 2001, 2010; Tennant 2011; Germano et al. 2013; B. Cypher, unpublished data). This often occurs because regulatory agencies require project proponents to fund the translocation effort itself, but fail to include (or may be legally unable to require) funding for follow-up monitoring. In other cases grant funding may be secured for the initial translocation and several months of monitoring, but long-term monitoring is left to the agencies or other entities, and fails to be a priority.

We recommend that post-translocation monitoring be required for at least three years on the translocation site. Three years was established as a baseline in a 2006 translocation to Allensworth Ecological Reserve, and allows for monitoring of at least three generations, which will ensure that reproduction is not only occurring but also is sustaining the translocated population (Germano et al. 2013). In the 2006 Allensworth translocation, study site-wide trapping occurred six months post translocation and then once per year in the fall for three years (Germano et al. 2013), which we suggest is a good model for future efforts. Another reason that at least three years is appropriate is that populations of small mammals typically fluctuate annually and, even though a translocation may appear successful in the first six months, it may fail in subsequent months due to a wide range of factors such as an increase in competitors or predators, or a change in other habitat conditions. Furthermore, monitoring and reporting on the success or failure of translocation efforts is integral to updating and refining recommendations and, ultimately, the future success of translocations of endangered kangaroo rats.

Conclusions

The Tipton kangaroo rat currently is known to occur at about 10 sites throughout its range, and populations have continued to decline or are unstable (Uptain et al. 1999, USFWS 2010). However, surveys have not been conducted on all remaining habitat parcels, and additional populations could be located in the future. The best option for conserving Tipton kangaroo rats is to protect all remaining parcels on which it occurs. Because this species is found on so few sites, however, recovery may also require that additional land be purchased and restored to native habitat conditions, and animals subsequently reintroduced. Furthermore, development is still occurring on lands inhabited by Tipton kangaroo rats, and mitigation measures may include translocating animals. The situation is similar for other endangered kangaroo rats, such as the giant kangaroo rat. Thus, more research on effective methods for translocating kangaroo rats is needed.

For Tipton kangaroo rats, a particularly pertinent issue is whether there are sites in the southern San Joaquin Valley that (1) have high quality habitat; (2) can be actively managed; (3) contain a high abundance of existing burrows but lack a current population of endangered kangaroo rats; and, (4) have no, or few, competitors. We have found that the lack of available sites has confounded translocation efforts in the past. A current list of potential translocation sites for rare species of kangaroo rats must be developed and maintained so that when translocation is considered, potential recipient sites can be quickly identified.

If our recommended criteria cannot be satisfied, then it is our opinion that translocations should not be attempted. Translocating individuals under less than optimal conditions substantially reduces the probability of success, and also raises ethical questions

regarding translocations as a means of protecting the species if, in fact, that is not the case. We suggest it would be better to place individuals in zoos or museums, use them in outreach programs, or use them for research (e.g., captive breeding or behavioral studies), rather than conduct translocations that have a low probability of success.

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