FEASIBILITY AND STRATEGIES FOR TRANSLOCATING SAN JOAQUIN KIT FOXES TO VACANT OR RESTORED HABITATS

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EXECUTIVE SUMMARY

The goal of this report is to assess the feasibility of reintroducing endangered San Joaquin kit foxes (*Vulpes macrotis mutica*) into vacant or restored habitats. Kit foxes are an integral component of arid upland natural communities in the San Joaquin Valley. They are no longer present on some formerly occupied lands due to past impacts or stochastic demographic events. However, an increasing amount of land is being retired from agricultural production and restored to habitat suitable for kit foxes. Natural colonization of these lands by kit foxes may be difficult due to the absence of connecting corridors to occupied habitat. Thus, reintroduction may be necessary and would contribute significantly to kit fox conservation and recovery efforts. However, reintroduction is a complicated process requiring significant preparatory work. In this report we have: conducted a literature review to review the techniques and success criteria employed in reintroductions of other species and the outcome of these efforts; developed criteria for selecting sites for kit fox reintroductions; identified a tentative list of lands potentially suitable for reintroductions; developed recommendations for strategies and techniques to be tested in reintroduction efforts; developed success criteria for kit fox reintroduction efforts; identified regulatory requirements to be addressed prior to reintroductions; and identified potential funding sources for reintroduction efforts.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The views expressed herein do not necessarily reflect the views or policies of the Central Valley Project Conservation Program, the U.S. Bureau of Reclamation, or the U.S. Fish and Wildlife Service.

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1. INTRODUCTION

San Joaquin kit foxes were once widely distributed in shrubland and grassland habitats in the San Joaquin Valley of California. Much of the habitat within the former range of this species has been converted to agricultural, industrial, and urban uses. As a result, the San Joaquin kit fox is listed as federally endangered and California threatened. Kit foxes currently persist in several populations of varying size (U.S. Fish and Wildlife Service 1998b).

For rare species such as kit foxes, population viability increases and risk of extinction decreases as both the number of individuals and the number of populations increase. Thus, a basic conservation and recovery strategy is to increase both the number of individuals and the number of populations. On lands currently inhabited by kit foxes, there may be some opportunities to increase fox numbers (e.g., through habitat management), but in general, kit foxes on these lands likely are near or at carrying capacity. Thus, the establishment of additional populations appears to offer the best opportunity to enhance kit fox numbers and improve the potential persistence of the species.

Lands exist in the San Joaquin Valley that are considered as suitable habitat for kit foxes, but are not presently occupied by kit foxes. In some cases, past impacts are responsible for the absence of kit foxes, while in other cases stochastic demographic events may have resulted in the disappearance of foxes from these lands. Also, an increasing amount of land in the San Joaquin Valley is being retired from agricultural production, and in some cases restored to habitat suitable for kit foxes. Colonization of these vacant and retired lands by kit foxes at times might be difficult. The lands may not be located near extant kit fox populations and/or there may not be adequate dispersal corridors to the lands.

Reintroduction, whereby individuals are taken from a source population and released in suitable vacant habitat, is one potential strategy for establishing new populations of kit foxes. This technique has been used successfully to establish new populations of a number of high-profile endangered species including gray wolves (*Canis lupus*), red wolves (*Canis rufus*), swift foxes (*Vulpes velox*), black-footed ferrets (*Mustela nigripes*), southern sea otters (*Enhydra lutris*), and California condors (*Gymnogyps californianus*). However, a number of factors need to be considered prior to reintroduction efforts to increase the probability of success. This is particularly important when dealing with an endangered species.

2. LITERATURE REVIEW OF ANIMAL REINTRODUCTIONS AND TRANSLOCATIONS

2.1. INTRODUCTION AND DEFINITIONS

Large numbers of animal extinctions during the last century raised awareness and concern about the fate of species that are currently in decline. Numerous reintroduction and translocation programs have been attempted in the past, covering a variety of bird, mammal, amphibian and fish species. However, many reintroduction efforts fail (Yalden 1993) and caution should be applied when planning future release programs. Several reviews published in recent years have assessed the success of reintroduction and translocation programs, and have made recommendations and guidelines for future programs (e.g., Breitenmoser et al. 2001, Fischer & Lindenmayer 2000, Reading & Clark 1996, Beck et al. 1994).

Throughout the literature the terms "reintroduction' and 'translocation' are broadly used, with varying definitions. The most widely accepted definition of reintroduction is provided by The World Conservation Union (IUCN): "an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct" (IUCN 1995).

The IUCN position statement on translocation (1987) defines translocation as "the movement of living organisms from one area with free release in another", and uses translocation as a blanket term covering reintroduction, introduction, and re-stocking. However, in the "Guidelines for Reintroduction" (1995), translocation is defined as the "deliberate and mediated movement of wild individuals or populations from one part of their range to another." Several other authors follow this definition (e.g., Griffith et al. 1989, Wilson & Stanley Price 1994). Translocation is most commonly used to either supplement declining populations or restore extirpated populations (Kleiman et al. 1994). However, other definitions discriminate between whether animals are being released into an area where they were historically present or not. For example Reading & Clark (1996) define reintroduction as "returning species to, and re-establishing them in, areas they once inhabited", and translocation as "establishing species in areas well-suited to them regardless of whether they once inhabited those areas."

For the purposes of this review, and indeed throughout this report, we shall use the term translocation, in accordance with the definition provided by the IUCN (1995), Griffith et al. (1989) and Wilson & Stanley Price (1994) of animals being moved from one part of their range to another. However, while discussing findings presented by other authors, we shall use the term utilized within those papers. In compiling this review, papers have been considered where animals have been either bred in captivity or removed from an existing wild population for release into suitable habitat. Both methods have similar criteria and problems, so, to facilitate this review, the terms reintroduction and translocation are used throughout, and are interchangeable.

The IUCN states that any release program should have the following objectives: a) to enhance the long-term survival of the species, b) to re-establish a keystone species (in the ecological or cultural sense), c) to increase or maintain biodiversity, d) to provide long-term economic benefits to local people, or e) to achieve a combination of all of the above (IUCN 1995, Kleiman et al. 1994). A further definition of the aims of reintroductions/translocations is “to establish a viable population of the species in an area in a way that does not constitute a physical or health hazard to local human or animal populations” (International Academy of Animal Welfare Sciences 1992).

2.2. COMMON ISSUES ASSOCIATED WITH REINTRODUCTION PROGRAMS

2.2.1. Expense

Cost is usually the single most restrictive factor associated with reintroduction programs (Schaller 1996, Stuart 1991, Stanley Price 1991), and therefore substantial funding is required (Kleiman 1996). Considerable financial support is required for routine expenses such as salaries, benefits, vehicles, equipment, and supplies, but also for specialized expenses such as animal caging and shipping, pre-release preparation and training, post-release monitoring, public outreach and education and habitat protection and management. The estimated total cost of the seven-year golden lion tamarin (*Leontopithecus r. rosalia*) reintroduction program was $1,083,005, with each surviving animal costing $22,500 (Kleiman et al. 1991). The U.S. Fish and Wildlife Service estimated the Mexican wolf reintroduction program would cost over $7,000,000 over nine years (U.S. Fish & Wildlife Service 1996). Therefore, it is imperative that before a new program is initiated a sound funding strategy is developed, preferably securing long-term funding for the entire duration of the reintroduction program.

2.2.2. Available habitat

Lack of available habitat is a significant potential limiting factor in reintroduction programs. Habitat loss commonly is one of the major factors in the decline of most currently endangered or extirpated species, and therefore it is likely that availability of suitable habitat for reintroduction will be limited. For reintroduction to succeed, an adequate area of suitable habitat should be available with an active protection and management program (Kleiman 1996). In some situations, a particular parcel of habitat is being restored, for example as a tourist attraction (Jungius 1985) or through mitigation (Williams et al. 1998) and such an area may provide suitable habitat. Yalden (1993) states the first essential of reintroduction planning is a natural area, with a sympathetic local human population. In addition, the release site must have adequate carrying capacity to sustain growth of the reintroduced population (Brambell 1977, Kleiman 1989). For example, the critically endangered Antiguan racer snake (*Alsophis antiguae*) is currently only found on Great Bird Island in the Lesser Antilles. While this island comprises part of the snake’s former range, and snake populations have successfully been increased through efforts of the Antiguan Racer Conservation Project the island has a carrying capacity to support only 100 individuals. Future conservation measures must, therefore, include the procurement of a new site within the snake’s former range (Daltry et al. 2001).

Modeling may aid in determining whether a proposed reintroduction should proceed by providing answers to questions related to viable population sizes relative to the available habitat. A feasibility study by Howells & Edward-Jones (1997) of a proposed reintroduction of wild boar (*Sus scrofa*) to Scotland concluded that there were not adequate amounts of suitable habitat available to sustain the minimum viable population. Thus, although management options were available to facilitate other aspects of reintroduction (such as supplementation to increase the gene pool, translocation between populations, and supplementary feeding) it is unlikely that a successful reintroduction of boar will transpire in the near future.

2.2.3. Available source animals

Removal of animals for translocation should not deplete or stress the donor population (Reading & Clark 1996). This is particularly important where rare species are involved. Also removed animals should fulfill relevant age and sex criteria to optimize chances of survival (Yalden 1993, Sarrazin & Legendre 2000). Wild individuals are preferable to captive bred ones due to the many problems associated with captive animals such as the high costs of captive breeding and insufficient behavioral skills for existence in the wild (Reading & Clark 1996). If animals are obtained from a captive population it is essential that this stock population is well managed and has sufficient surplus animals (Kleiman 1996). In the case of the natterjack toad (*Bufo calamita*) recovery program in Britain, efforts were made to increase the number of individuals in wild populations (e.g., by providing extra breeding pools) prior to removal of spawn for reintroduction at newly prepared sites so as not to increase stress on existing populations (Denton et al. 1997). The reintroduction program for golden eagle (*Aquila chrysaetos*) recovery in Ireland strictly limits chick removal to nests containing twins to reduce the risk of depleting source populations in Scotland (O'Toole et al. 2002).

2.2.4. Organizational problems

Most reintroduction programs are conducted by a collaborative group of organizations, including government, non-government, and academic or research organizations. This multi-level organizational structure is likely to be a major variable in the success or failure of reintroduction programs (Breitenmoser et al. 2001, Reading & Clark 1996). If a large team is well coordinated, then it is likely that this will have a positive effect on the program (Kleiman et al. 1994); however, a large team that does not work well together, may jeopardize the reintroduction effort. Reading & Clark (1996) suggested that factors that may have a detrimental effect on reintroduction success are variables such as: poor matching of organizational structures to the reintroduction task, delegating implementation to an individual or organization lacking the necessary expertise, issuing conflicting directives, depending too heavily on other organizations, and exercising weak leadership or excessive discretion. In order to reduce the negative effects of these variables, it is suggested that all organizations clearly define their individual roles, responsibilities, and commitments (long-term) from the outset (Mallinson 1991). Both the Canadian swift fox and the Colorado lynx (*Lynx canadensis*) reintroduction programs, may have suffered from a lack of organizational structure. During the swift fox program, primary responsibility shifted frequently, from a private, to a university, to a government initiative. In the case of the Colorado lynx program, inadequate experience on the advisory team is considered to have attributed to the starvation of released animals (Breitenmoser et al. 2001).

Kleiman et al. (1994) state that the most successful translocations appeared to result from those programs conducted by several institutions incorporating many resources. For example, the Peninsular Bighorn Sheep (*Ovis canadensis*) reintroduction comprised a team drawn from the California Department of Fish and Game, the U.S. Bureau of Land Management, the U.S. Fish and Wildlife Service, and the Bighorn Institute. Ostermann et al. (2001) report that while not achieving all five major aims of the reintroduction (survival and recruitment in captive herd, survival of released animals, recruitment of released animals, growth of population, establishment of viable population), the diversity of expertise of the various members of the team allowed for evaluation of differing aspects of the program, such as survivorship, and environmental conditions. However, the authors do not distinguish whether large teams create success, or if large teams tend to be created for potentially successful projects.

2.2.5. Impact on local people

Conservation of animals in areas where they are likely to come into conflict with humans is extremely problematic. In general, this appears to be amplified with carnivores, where real or perceived conflicts between humans and animals can be a serious impediment to conservation. Carnivore-human conflict can arise through attacks on humans, predation on livestock, predation on game species, predation on other endangered wildlife, consumptive use of carnivores, conflict over land, and disease (Sillero-Zubiri & Laurenson 2001). When reintroducing any animal, particularly carnivores, the feelings of the local community, and the impact of the project on this community must be carefully assessed and considered. The attitude of the community can have significant implications on the likelihood of success of a project. For example, the destruction of suitable habitat for an endangered species is often a result of the activities of the local people, and therefore the community must be involved from the early stages of planning a release to ensure that they become collaborators and are not hostile to the program (Kleiman 1989). An assessment of the impact of both lions (*Panthera leo*) and elephants (*Loxodonta africana*) on rural agriculturists in East Caprivi in Namibia over a five-year period found that lions were of greater financial impact on farmers, while elephants were responsible for the majority of conflicts. Locally, elephants have high densities, while range-wide densities have diminished, thus causing conflict between farmers and conservationists. Attempts have been made to reduce these clashes using deterrents such as electrical fencing, trip-alarms and warning calls, and by improving relations between local communities and conservationists (O'Connell-Rodwell et al. 2000).

Local communities often view reintroductions as a threat to themselves, their livestock, or their crops. The grey wolf in North America particularly exemplifies this conflict. In a survey of attitudes towards wolf reintroduction in Northwestern Montana, a high proportion of those sampled either agreed or strongly agreed that "a person alone outdoors in wolf country is in danger of being attacked" (Tucker & Pletscher 1989), even though no human deaths were attributed to wolves throughout the twentieth century

(Kellert et al. 1996). Similar responses were reported in a survey in Colorado (Pate et al.. 1996). Many respondents to questionnaires demonstrated an increased idea of the possible level of threat to livestock posed by wolves (McNamee 1986, Tucker & Pletscher 1989). In reality, if considering all ranches in British Columbia, Alberta, and Minnesota, less than 5% experiences losses caused by wolves each year (Fritts 1982, Tompa 1983). This demonstrates the need for an education component within reintroduction programs to facilitate continued public support, protection and co-operation (Kleiman 1989, Phillips 1990, Chivers 1991, Kleiman et al. 1994). An effective strategy of the natterjack toad recovery program was to restrict grazing regimes so they resembled those practiced in earlier centuries. This was accomplished through management plans constructed with the aid of local farmers (Denton et al.. 1997).

While the initial local reaction tends to forecast the potential detrimental effects of reintroduction, recovery programs may benefit local people if approached correctly. For instance, the yellow-shouldered Amazon parrot (*Amazona barbadensis*) reintroduction program in Venezuela provided employment for local people, and used local businesses where possible when procuring supplies (Sanz & Grajal 1998). Other opportunities also exist, including greater employment prospects as a direct consequence of the project itself, such as promoting ecotourism in reintroduction areas. Careful consideration of the impact to local people of the reintroduction of a listed species is essential. Implementation of the swift fox reintroduction onto Blackfeet Tribal Lands in Montana was facilitated by the fact that the species was not a federally listed species, as the Tribal Council were more inclined to look favorably on the release of a species that did not place significant restrictions on human activities at the release site area (Newbreast, pers. comm.). The Blackfeet Tribe obtained further local support by incorporating outreach programs regarding the swift fox releases into education programs and ecotourism. Therefore by encouraging positive effects on the lives of people in the area, more public support is likely to be generated.

2.2.6. Lack of Documentation

There is a deficit of available detailed information on existing reintroduction programs, as well as a lack of external evaluation and peer-review (Griffith et al. 1989, Beck et al. 1994, Kleiman et al. 1994, Breitenmoser et al. 2001). Beck et al. (1994) were able to obtain information on less than 50% of projects known to have been involved with the reintroduction of captive-born animals. This lack of information makes it difficult to determine the success rates of projects and hence to produce detailed criteria as guidelines for future programs (Beck et al. 1994, Kleiman et al. 1994). Records on failed projects are essential as they provide information on unsuccessful approaches that can be avoided on future relocation efforts (Reading & Clark 1996). With an increase in the levels of documentation of both successful and unsuccessful reintroduction programs, guidelines would be more definitive and useful to those planning future reintroductions. To this end, the IUCN prepared a set of guidelines for reintroduction, with the aim of ensuring that reintroductions achieve their intended conservation objectives (IUCN 1995).

2.3. *CONSERVATION GENETICS*

The inclusion of molecular genetic techniques in animal conservation has become both widely accepted and welcomed as new methods for analyzing individuals, populations and species have become more advanced (Haig 1998). Conservation and population genetic studies have progressed through the use of allozyme, mitochondrial DNA (mtDNA), minisatellite, and microsatellite markers (e.g., Ferguson et al. 1995, Haig 1998).

Declining populations results in increased vulnerability to various influences - environmental, genetic and demographic. Long-term retention of sufficient genetic variation for future adaptation or re-establishment is a major goal of conservation genetics (Hedrick & Miller 1992). When a species is reduced in numbers, it is liable to suffer increased levels of inbreeding. Consequently, a loss in genetic variation and the potential expression of deleterious genes is observed, thus leading to a greater risk of extinction (Frankham 1995a) due to susceptibility to adverse influences, such as climate, pollution, disease and parasites (Pray et al. 1994, Frankham 1995a, Heschel & Paige 1995). Previous research has highlighted the existence and potentially detrimental effects of inbreeding depression in both captive and natural populations (e.g., De Bois et al. 1990, Stockley et al. 1993), therefore care should be taken when working with endangered species to minimize the risk of further compromising the species through poor breeding managment.

Inbreeding effects and loss of variation can be alleviated through the introduction of immigrants (Heschel & Paige 1995), as has been suggested for endangered kokako (*Callaeas cinerea wilsoni*) populations in New Zealand (Hudson et al. 2000). Introduction of unrelated animals to a small, inbred population improves reproductive fitness, thus allowing for increased genetic variability. However, due care must be taken as regards outbreeding depression, which increases the frequency of heterozygotes within a population by introducing new alleles, but may lead to the breakdown of co-adapted genes (Frankham 1995a). In addition, Storfer (1999) cautions against the potentially detrimental effects of artificially enhanced gene flow (e.g., through translocation), such as homogenized fixed genetic differences or reduced potential for future local adaptation.

In captivity, when there are no longer populations present in the wild, the population is considered ‘closed’ in that the only new source of genetic variation will be from mutations occurring within the captive colony (Ryder & Fleischer 1996). This can also apply to isolated wild populations. Isolation is often a result of habitat fragmentation, which can restrict gene flow and the maintenance of genetic variation (Storfer 1999). Species with remaining wild populations potentially provide a source of variation through periodic and carefully planned introductions to the captive population, enabling larger portions of the wild gene pool to be preserved (Ryder 1986, Lacy 1987). The more of a gene pool that is preserved, the greater the chances that the population will adapt to varying environmental conditions (Hedrick & Miller 1992).

In many cases only captive bred animal are available for use in a reintroduction program. For several species, the only alternative was to remove some of the last remaining individuals from the wild and establish a captive breeding colony to provide future animals for release. Examples include the black-footed ferret (*Mustela nigripes*), red wolf (*Canis rufus*), Californian condor (*Gymnogyps californianus*), Arabian oryx (*Oryx leucoryx*), and scimitar-horned oryx (*Oryx dammah*) (Seal 1991) programs.

Regardless of whether a reintroduction program uses wild or captive source populations, it is essential that individuals representing maximum genetic variability are selected (Griffith et al. 1989) to alleviate the risk of founder effects (Templeton 1990, Reading & Clark 1996). The retention of genetic variation increases the basis for adaptive evolution (Ballou & Foose 1996). When a population is descended from a small number of founders, the probability of inbreeding increases and may be inevitable (Hedrick & Miller 1992). Thus, when feasible, a large number of founding animals should be selected (minimum numbers ranging from 20-30, but see Frankham 1995b for additional considerations) which are unrelated and are as representative a sample of the gene pool as possible (Ralls & Ballou 1986, Frankham 1995a). Loss of variation may be further exacerbated by unequal levels of reproduction from founders (Frankham 1995a). The genetic contribution of founders and loss of founder alleles due to genetic drift (changes in gene frequency due to loss of alleles through chance, not as a result of selection, emigration, or immigration; Abercrombie et al.. 1992) and pedigree bottlenecks can be assessed, as can levels of genetic diversity, the genetic importance of individuals, and inbreeding coefficients (Ballou & Foose 1996).

Extensive knowledge of the genetic attributes of a captive population will allow for optimal management while animals are retained in captivity. The principles outlined above have mainly been expounded from studies of the creation of captive populations, however the same principles can be applied to the founding of a reintroduced population.

Monitoring the genetic component of populations can be conducted following analysis of basic pedigree and demographic attributes. To achieve the desired level of gene preservation, a number of genetic management tools can be applied as necessary. Management procedures may include maintaining parentage records, monitoring inbreeding and selection, monitoring of genetic diseases, and the control of breeding of founders and migrants.

Molecular genetic research techniques have advanced considerably in recent years. Methods used include chromosomal studies, protein electrophoretic studies, and blood-typing studies. The development of VNTR (variable number tandem repeats) DNA markers (both minisatellites and microsatellites) and the polymerase chain reaction (PCR) for DNA fingerprinting allows almost conclusive evidence of parentage and relatedness to be relatively easily obtained (Morin et al. 1994, Breen et al. 1995, McDonald & Potts 1997), and often prove more dependable than the traditional methods of observational data (Ashley & Dow 1994). Microsatellites have been used to verify parentage in a variety of species such as chimpanzees (Ely & Ferrell 1990, Morin et al. 1994), mongoose (Keane et al.. 1994), lion-tailed macaques (Morin & Ryder 1991), armadillos (Prodöhl et al. 1998), lions (Gilbert et al. 1991), and foxes (Gilbert et al. 1990). The relative ease of microsatellite techniques has resulted in their widespread use in the genetic management of endangered species.

2.4. APPROPRIATE BEHAVIOR SKILLS

Loss of genetic variation and genetic adaptation to captivity are only some of the risks of long-term maintenance in captivity. Captive populations will also require monitoring to ensure that long-term captivity does not degrade behavioral skills essential for survival following release. Releases of captive bred African wild dogs, for example, revealed a lack of survival skills such as hunting, (Woodroffe & Ginsberg 1999), predator avoidance (Woodroffe & Ginsberg 1999, Frantzen et al.. 2001) and lack of human avoidance, which most likely resulted from associating humans with food (Woodroffe & Ginsberg 1999). Other captive-bred canids have demonstrated a similar lack of survival skills. Wolves released in Alaska were ineffective hunters and approached humans (Henshaw et al. 1979), and a high proportion of captive-bred swift fox were killed by coyotes following release (Carbyn et al. 1994). One well-known example of limited behavioral suitability was the failure of early releases of golden lion tamarins because released individuals became disoriented and demonstrated a lack of ability to travel through unfamiliar terrain (Kleiman et al. 1986).

In many instances, attempts have been made to prepare animals for release by maximizing appropriate pre-release experiences (Biggins et al. 1999) and reducing exposure to unsuitable stimuli (Valutis & Marzluff 1999). The most common of these measures endeavor to increase levels of aversion to potential threats, most frequently by teaching predator avoidance. This entails using classical conditioning to link predator models such as stuffed animals (e.g., McLean et al. 2000) or trained dogs (e.g., Griffin et al. 2000) with aversive events.

Wild populations of a species are likely to be subject to varied selective pressures, resulting in diverse behavioral phenotypes. The ultimate aim is to select individuals with the highest potential to survive and breed in the wild with minimal pre-release preparation (Kleiman 1996, Woodroffe & Ginsberg 1999). Furthermore offspring should demonstrate the behavioral skills required to survive in the wild. Kleiman (1989, 1996) describes the six main types of behavior that release candidates must exhibit: (1) avoidance of predators, (2) acquisition of food, (3) appropriate interaction with conspecifics, (4) the ability to find or construct shelter, (5) ability to locomote on complex terrain, and (6) ability to orient and navigate in a complex environment.

In recent years, recognition of variation in behavior among non-human individuals has gradually increased as highlighted by studies on non-human species (Spencer-Booth & Hinde 1969, Slater 1981, Caro & Bateson 1986, Clark & Ehlinger 1987, Mather & Anderson 1993, Hansen 1996, Coleman & Wilson 1998). Individual behavioral variation may well have significance for management of captive animals, whether individuals are intended for human consumption, long-term captivity, or reintroduction. The International Academy of Animal Welfare Sciences recognizes the importance of individual variation and includes this under the heading ‘character’ when listing factors for selection of animals for reintroduction (International Academy of Animal Welfare Sciences 1992).

The existence of different personalities may reflect adaptive strategies within a species (Wilson & Richards 2000), which in turn may, if heritable, be subject to natural selection (Wilson et al. 1994). One component of personality, which may be significant in terms of natural selection, is boldness. Individual variation in terms of levels of fearfulness, or boldness and shyness, has long been considered by psychologists as one of the most crucial aspects of variation in humans (Coleman & Wilson 1998) and has been extensively studied (e.g., Thomas & Chess 1977, Plomin & Dunn 1986, Kagan et al. 1988, Matheny 1989, Kagan 1991). However, the distribution of research amongst non-human species has been limited, with the majority of previous studies focusing on canids (Fox 1972, Harri et al. 1995), fish (Huntingford & Giles 1987, Wilson et al. 1993, Wilson et al. 1994, Coleman & Wilson 1998); cats (Lowe & Bradshaw 2001), octopus (Mather & Anderson 1993), and ungulates (Lyons et al. 1988, Réale et al. 2000). Responses to unfamiliar objects or events vary among individuals but are consistent within individuals, and are displayed early in development (Kagan et al. 1988).

This individual variation in boldness/shyness may have important implications for survival and reproduction (Buirski et al. 1973). Levels of boldness are subject to natural selection (Huntingford & Giles 1987) and therefore inappropriate levels of boldness will have deleterious effects on fitness. This is important for any release program, as the object of release is to provide behaviorally adept individuals that will survive and reproduce in the wild. If there is a substantial variation in boldness of individuals destined for release then some are likely to suffer reduced survival and reproduction as a consequence. This was demonstrated in a recent study of reintroduced swift fox where animals that died following release were those with overly high levels of boldness (Bremner-Harrison et al. 2004). Therefore, if captive-bred animals are to be released into the wild, it is important that they be maintained in as natural surroundings as possible and individuals should be given maximum exposure to stimuli that are likely to be encountered in the wild to increase pre-release experiences.

2.5. SPECIFIC CONSIDERATIONS ESSENTIAL FOR RELOCATION PLANNING

2.5.1. General Translocation Criteria

Several authors have published what they suggest to be the most important criteria to address when proposing translocation of a species. These criteria range from factors that should be considered when determining whether translocation is the most suitable course of action to the appropriate procedures to follow. Kleiman et al. (1994) provide one of the most extensive lists of criteria to be considered, covering a total of 13 different points categorized as species, environmental, biological, and political considerations (Table 1).

Table 1. Criteria for animal reintroductions from Kleiman et al. 1994.

Condition of species	1) need to augment wild population 2) available stock 3) no jeopardy to wild population
Environmental conditions	4) causes of decline removed 5) sufficient protected habitat 6) unsaturated habitat
Biopolitical conditions	7) no negative impact for locals 8) community support exists 9) GOs/NGOs supportive/involved 10) conformity with all laws/regulations
Biological and other resources	11) reintroduction technology known/in development 12) knowledge of species biology 13) sufficient resources exist for program.

Once reintroduction has been identified as the most suitable approach for conserving a species, the effort comprises several distinct phases. Stuart (1991) describes the main stages as feasibility study, preparation phase, release or introduction phase, and follow-up and maintenance phase. Chivers (1991) provides a slightly more detailed list including capture, transport, captive breeding and training for release in his catalogue of essential steps. In a review of mammal reintroductions, Stanley Price (1991) stresses the importance of the feasibility study as an opportunity to plan for as many eventualities as possible, including using this period of study to address policy issues. The particular planning process implemented in a given situation likely will be a function of available resources, level of urgency, attributes of potential source populations and release sites, legal issues, and of course the experience as well as biases of individuals involved in the planning process.

2.5.2. Site selection criteria

The IUCN (1995) provides clear guidelines regarding site selection for animal translocations or introduction. Recommendations include ensuring that (1) all habitat and landscape requirements of the species are met; (2) any habitat changes that occurred since extirpation are identified and rectified; and (3) any human-inflicted degradation be remedied through a habitat restoration program. Also, year-round availability of food and water has to be assessed, along with the presence/absence of other species, particularly potential predators or competitors. If the target species is absent, reasons for this must be identified and rectified. If the species is present, the carrying capacity of the habitat should be assessed (Chivers 1991). The original cause of decline should be removed prior to reintroduction (e.g., Kleiman 1989, Ounsted 1991). Additionally, Merrill et al. (1999) suggest looking at the presence/absence of humans within the prospective habitat, human activity levels, and assessing the likelihood of conflict.

2.5.3. Source populations and release animals

The source of release animals should be carefully considered, particularly whether to use captive bred animals or to translocate from existing wild populations. Regardless of source, several criteria apply when selecting animals: genetics, age, sex, health (Dixon et al. 1991), and behavioral variation (Bremner-Harrison et al. 2004). Genetically diverse animals are essential to maximize genetic variability and founder genes within the reintroduced population (Dixon et al. 1991). Although older animals may be more experienced, younger animals may be more adaptable. Also, sex ratios of released animals should be selected that optimize potential reproductive success (e.g., 1:1 ratios for monogamous species and skewed ratios for polygamous species. Obviously healthier animals will have higher survival probabilities. Finally, as discussed previously, if behavioral profiles can be assessed then it may be advantageous to initially select animals exhibiting profiles that will maximize survival and reproduction in the wild.

2.5.4. Organization and permitting

The IUCN (1995) recommends that a multi-disciplinary team be formed to coordinate translocation/reintroduction efforts. This team should include or have access to technical advice for each phase of the program. In addition, it is recommended that the program should not proceed until it has the approval of all relevant government agencies, and with the cooperation of national and international conservation organizations where applicable (Stanley-Price 1991).

Permitting requirements will vary depending on the individual reintroduction or translocation program. These requirements will vary according to whether animals are being obtained (captive or wild-caught) and released within-state, between states, or internationally. Requirements will differ for programs using captive-bred versus wild-caught translocated animals. Within the U.S. permits will be required from the appropriate state organizations, and federal permits from the U.S. Fish and Wildlife Service as well as state permits being required if the species is federally or state listed. Additional permits may be required from tribal, private, or local entities depending upon the locations of source populations and release sites.

2.5.5. Financial aspects

There is limited information regarding specific costs of relocation projects or sources of funding. In a review of 180 relocation studies, Fischer & Lindemayer (2000) state that only 6 studies reported costs, and only one of these provided a breakdown of costs and funding sources. Ideally, funding should be secured for the duration of the entire project (Stanley-Price 1991), although in reality, most funding bodies award grants on an annual or sometimes multi-year basis.

Projection of costs should cover all aspects of the project. For example, Kleiman et al. (1991), include costs for expenses such as vehicles, equipment and supplies, and personnel in their description of the golden lion tamarin reintroduction project.

2.5.6. Release strategies

Devising a release strategy incorporates decisions regarding group composition; whether to include behavioral training; release patterns and techniques; acclimatization; and timing of releases (IUCN 1995). Initial release group composition should comprise of an appropriate ratio of males to females, according to the breeding strategy of the species, i.e., monogamous, polygamous, or polyandrous. Release group composition in subsequent releases will continue to provide animals in accordance with the relevant breeding strategy while also taking into account the existing population structure surviving from previous releases.

As discussed in Section 2.4, some form of behavioral training may be required for captive-breed animals to familiarize them with food sources, predator avoidance measures or locomotory requirements, or for translocated animals that will be exposed to an unfamiliar food source or predator. The time and resources required to complete this training should be added into the release plan to allow for adequate animal preparation.

Release techniques vary widely with the extremes at either end of the scale being (1) hard release, whereby animals are taken to the release site and set loose immediately without an acclimatization period, training, supplemental feeding or protection; and (2) soft releases, whereby the animals are often placed in a temporary pen and maintained for a period of days to years prior to being released. Most programs utilize a combination of these extremes or an intermediate strategy. Acclimatization to the release site largely depends on the release technique used. If animals are to be released using soft releases, a period of acclimatization is automatically incorporated into the release strategy. The length of the acclimatization period will generally vary according to the distance that animal are transported and differences between the source and release locations. Chivers (1991) recommends that transportation stresses be kept to a minimum, and that if animals are coming from overseas that a period of acclimatization be incorporated into the release timing. Releases should be timed to correspond with both the natural dispersal period of the species, and periods of high prey abundance.

Disease screening is highly recommended to prevent introducing a new pathogen into an area and to avoid releasing animals into an area where virulent pathogens are endemic. Woodford & Kock (1991) advocate individual health checks, including screening for ecto- and endo-parasitic infections; screening of sera for appropriate antibodies; examination of blood smears; and where appropriate, specific virus isolations. They also suggest marking individual animals to facilitate epidemiological questions. With captive animals, a full veterinary history should be obtained, and for wild-caught stock the local and regional disease patterns should be checked (Woodford & Kock 1991). Disease transmission risks will be reduced if the species is absent from the release site (Chivers 1991).

2.5.7. Monitoring Strategies

Monitoring should be conducted to assess the success of reintroduction and translocation programs. Methods of monitoring released animals should be appropriate for the species in question and should be adequate to address monitoring objectives (e.g., measuring survival reproduction, population size). The method, or methods, selected should cause minimal levels of disruption and provide maximum levels of information. Current methods used to monitor reintroduced species include trapping, mark-recapture, radio-telemetry, track-plates, spotlighting, hair-snares, and scat-detection dogs. The methods selected will be influenced by factors such as budget and labor-intensity, as well as types of information need. Disease monitoring also should be carried out, either through regular sampling of the population for blood and fecal matter for hematology, biochemistry and serology, bacteriology and parasitology examinations, or through post-mortem examinations (Woodford & Kock 1991).

2.5.8. Success criteria

The success of a project should be evaluated to determine whether goals were achieved and to gather information useful for improving any future efforts (Schaub et al. 2004). In general, a relocation program aims to produce a viable self-sustaining population (Griffith et al. 1989) with a positive growth rate (Matson et al. 2004). Defining whether or not a project has been successful can be difficult due to the large timescales sometimes required to establish whether a population is self-sustaining, particularly with species with slower reproductive rates (Matson et al. 2004). However, more intermediary success criteria may be used for each stage of the project to determine step-by-step achievements.

Kleiman et al. (1991) discuss basing the success criteria on the species. They suggest that survival is the appropriate metric for a *k*-selected species (i.e., one with a long lifespan and reproductive history) and that reproductive output and infant survival are the appropriate metrics for a r-selected species (i.e., short inter-birth intervals and large litter size). The criteria should incorporate targets regarding levels of survival, reproduction, home range establishment, and genetic variability in order to fully evaluate the success of a reintroduction program.

2.5.9. Factors influencing success

In a review of previous animal relocations, Fischer & Lindenmayer (2000) found a greater probability of success in projects where a large number of animals were released overall, either as one release or several releases over time. Of course, number of animals released will depend upon available stock, financial resources, logistic constraints, and other factors. In addition, it was determined that projects where the original cause of decline was removed tended to be more successful (Kleiman 1989, Fischer & Lindmayer 2000), such as the removal of introduced predators or modification of agricultural practices. Griffith et al.. (1989) found that translocations that utilized suitable habitat, had large founder populations, and released wild caught animals (versus captive bred) were more likely to be successful. Thus, it is important to identify specific factors which may affect success rates for the species in question, such as optimal population size, and potential or known threats to the species in general as well as the released population.

A review by Beck et al. (1994) of 145 reintroductions revealed that just 16 programs were considered successful. In a review of 165 carnivore reintroduction programs, 69 were classed as successful, 44 as failed, and 14 as uncertain, 24 as unknown and 15 as still in progress (Breitenmoser et al. 2001). Thus it is imperative that any new reintroduction program incorporate as much planning as possible, and utilize available guidelines to maximize probability of success.

2.6. CASE STUDIES OF PREVIOUS CARNIVORE REINTRODUCTION PROGRAMS

Several carnivore reintroductions have been selected as case studies that might provide insights for future kit fox reintroductions. In each of these case studies, information has been included regarding the considerations described above where available from the literature.

2.6.1. Black-footed Ferret

The black-footed ferret is an example of a successful North American reintroduction project. Once widespread in the shortgrass prairie regions, their distribution reflected that of their main prey, prairie dogs (*Cynamys spp.*) (Nowak & Paradiso 1983, U.S. Fish & Wildlife Service 1988, Thorne & Oakleaf 1991). By the 1970s however, the black-footed ferret was thought to be extinct (Dobson & Lyles 2000) as a combined result of the decline in prairie dog numbers, extensive loss of habitat, and widespread disease (Nowak & Paradiso 1983, U.S. Fish & Wildlife Service 1988, Thorne & Williams 1988, Brussard & Gilpin 1989, Biggins et al. 1998).

An initial attempt at captive breeding was made after a population of ferrets was discovered in South Dakota in 1964. Nine ferrets were removed from this location and placed in the Patuxent Wildlife Research Centre (Thorne & Oakleaf 1991). These ferrets produced litters but failed to raise the young, and the last of this captive population died in 1978 (Biggins & Godbey 1995).

In 1981, a large population of black-footed ferrets was discovered in Wyoming, resulting in a second captive breeding program being initiated in 1985 (Dobson & Lyles 2000) with the ultimate goal of reintroduction (Biggins et al. 1999). Molecular methods were employed from the outset to determine levels of genetic variation present in founders and the numbers required for an effective captive population to maintain 90% of genetic variation in the wild. The Species Survival Plan outlined the importance of molecular techniques in mate selection to conserve genetic diversity within the colony (Thorne & Oakleaf 1991).

As a means of assimilating as much behavioral information as possible prior to black-footed ferret releases, studies were conducted on Siberian polecats (*Mustela eversmanni*) to examine the development of food searching and predator avoidance behavior (Thorne & Oakleaf 1991, Biggins et al. 1999). This information was later supplemented from studies conducted on animals reared in enriched environments and in enclosures containing resident populations of prairie dogs (Miller et al. 1990a, 1990b, Biggins et al. 1998), in addition to studies of both trial and actual reintroductions on polecats and black-footed ferrets (Reading et al. 1996). Black-footed ferrets were initially reintroduced in Shirley Basin, Wyoming in 1991, after a population had been established in captivity (Reading & Clark 1996, Reading et al. 1996, Biggins et al. 1999, Vargas & Anderson 1999, Dobson & Lyles 2000). While this reintroduction was initially considered successful, a sylvatic plague epidemic ultimately killed all the ferrets and their prey.

From 1987 to 1999 over 3000 additional ferrets were produced in captivity providing ferrets for reintroduction in South Dakota, Montana, and Arizona, with future sites identified in Colorado, Utah, and New Mexico (Dobson & Lyles 2000). Animals released in Montana and South Dakota have shown promising survival and reproduction (Reading et al.. 1996). The black-footed ferret recovery team used initial setbacks and problems as a means of improving their methods, and adapted accordingly. The success of black-footed ferret releases is largely attributed to the high levels of pre-release preparation (e.g. predator aversion, opportunity to develop hunting skills) that the ferrets underwent and lessons learned from previous attempts at reintroduction. Survival rates were greatly increased when ferrets were reared in large enclosures with exposure to prairie dogs (Lockhart et al. 1998, Biggins et al. 1999, Dobson & Lyle 2000). This also reduced dispersal rates and increased the number of successful reintroductions by a factor of four (Dobson & Lyle 2000). While the reintroduction program is currently considered a success, future achievements rely on the availability of suitably sized prairie dog colonies and disease prevention strategies (Reading & Clark 1996).

2.6.2. Mexican wolf

The Mexican wolf, a subspecies of the grey wolf, historically occurred in southern North America, primarily Mexico and the Southwest U.S. (Parsons 1998). Mexican wolves were extirpated in the United States by 1970 through a number of eradication efforts, including control efforts arising from livestock conflicts (U.S. Fish & Wildlife Service 2003), and from bounties (Parsons 1998). Increased livestock predation is thought have been a result of decreasing ungulate populations and increasing livestock numbers in the American southwest during the late 1800's and early 1900's (Parsons 1998). In 1976, the Mexican wolf was designated Endangered in the United States.

A recovery plan was developed, detailing the objectives for Mexican wolf conservation, such as maintaining a captive population and re-establishing wolves within their historic range (U.S. Fish & Wildlife 2003). The recovery area consists of 4.4 million acres (Sefscik 2002), comprising the whole of the Apache and Gila National Forests in Arizona and New Mexico (U.S. Fish & Wildlife 2001). The original source of decline appeared to have been removed, as ungulate populations had recovered and livestock numbers had declined (Parsons 1998) thus reducing the risk of conflict. An inter-agency field team was set up to monitor and manage the reintroduction program (U.S. Fish & Wildlife 2003). The recovery program was split into two sections: the creation of a Mexican wolf captive breeding program, and the reintroduction effort (U.S. Fish & Wildlife 2001). Over time, the organization behind the recovery program has been restructured. In 2002, state and tribal organizations assumed lead responsibility for the reintroduction effort from the U.S. Fish and Wildlife Service (U.S. Fish & Wildlife 2002). In addition, two new groups were formed to assist with the recovery. The Mexican Wolf Oversight Committee, consisting of members of each of the primary cooperating agencies, was set up to provide guidance to the Interagency Field Team on policy issues (U.S. Fish & Wildlife 2003). The Mexican Wolf Adaptive Management

Work Group was also established to provide an open forum for interested parties that wished to participate in the program.

In 1977, a captive breeding program was implemented. Subsequently, five wolves were captured between 1977 and 1980 in Mexico, under the U.S. and Mexican Species Survival Plan, to be held as captive breeding stock (U.S. Fish & Wildlife 2003). This group was designated the original 'Certified' lineage (Parsons 1998). A further two lineages were later certified in 1995 for captive breeding, giving a total of 7 founders (U.S. Fish & Wildlife 2004a).

The captive breeding program is managed by the American Zoological and Aquarium Association (AZA) as part of their Mexican Wolf Species Survival Plan, thus affording it support from all AZA members. The program co-ordinates wolf movement and breeding between the various facilities holding wolves. In 2003, approximately 250 wolves were held in over 40 facilities throughout the U.S. and Mexico (U.S. Fish & Wildlife 2003). The breeding program operates under the premise that a primary goal is reintroduction (U.S. Fish & Wildlife 2001), and thus is managed accordingly, with breeding and transfers planned at an annual meeting. The breeding population is coordinated to minimize inbreeding and retain genetic diversity of the founders (Parsons 1998). The captive lineages have been assessed and no evidence of inbreeding depression has been detected (Kalinowski et al. 1999).

Wolves are selected for reintroduction based on stringent criteria, including genetic makeup, reproductive performance, behavioral criteria and physical suitability (U.S. Fish & Wildlife 2001). Following selection, release candidates are sent to one of three facilities where they undergo release preparation, such as minimal human contact to promote pack structural development, simulated prey feeding, and health assessments (U.S. Fish & Wildlife 2003).

The reintroduction strategy called for ≥ 100 wolves to be released into the Blue Range Wolf Recovery Area (BRWRA) in Arizona and New Mexico, with the White Sands Wolf Recovery Area being retained as an additional site should the 100-wolf objective not be reached at the BRWRA. Releases were to comprise an annual release of 3 family groups of 10-15 wolves for 3-5 years (Parsons 1998). The plan stated that the expected population target would be reached within 8-10 years through natural reproduction. The released wolves were classified as a "non-essential experimental population" (U.S. Fish & Wildlife Service 1998a) to allow for management flexibility.

In 1998, the first releases took place, with 11 Mexican wolves released into the primary release zone of the Apache National Forest within the BRWRA (Parsons 1998). Releases and translocations consisting of individuals and family groups continued through 2003 in various locations within the BRWRA (U.S. Fish & Wildlife 2004). By 2003, there were an estimated 50 - 60 wolves in the BRWRA, (Arizona Game & Fish Department 2004) consistent with the Environmental Impact Statement predictions of 55 wolves in six years (U.S. Fish & Wildlife Service 1996).

Wolves were relocated using a number of methods. Releases were classed as those wolves that were released directly from captivity, while translocations were free-ranging wolves that were captured in one area and moved into another, regardless of whether they spent a period in captivity prior to release. Three release strategies were used: hard, soft, and modified soft. Hard releases were when a wolf was released directly from a crate into the wild. Soft releases were when the wolves were held in an enclosure for 1 to 6 months until acclimated and then released. Modified soft releases were when the wolf was held in a mesh enclosure at the site, and freed themselves by tearing through the mesh, generally between 1 day and 2 weeks. All adult wolves were radio-collared prior to release/translocation and monitored weekly. In addition, population counts were conducted on a yearly basis. These were reinitiated at the start of each year by counting the number of collared individuals, and then adding estimations of uncollared animals throughout the year (U.S. Fish & Wildlife Service 2004a).

Prior to the start of the recovery effort, residents in the recovery area were polled to determine public and political opinions towards wolf reintroduction (Parsons 1998). In order to keep the general public and stakeholders informed regarding the project, outreach activities have been performed on a regular basis to disseminate information (U.S. Fish and Wildlife Service 2003). Education goals have been reached through the development of teacher's wolf workshops by the Information and Education Branch of the Arizona Game and Fish Department (U.S. Fish & Wildlife Service 2004a). The U.S. Fish and Wildlife Service's Mexican Wolf webpage provides monthly updates on each of the wolf packs, combining information from monitoring efforts and public sightings. Updates from 26 March 1998 to the most recent records are available.

Yearly reports and reviews have been complied, providing both data updates and evaluations of the project as it progressed. In particular, a "Three Year Review", and "Five Year Review" were designed not only to provide an overview of the project, but also to address any particular concerns and developments that had been identified. The Five Year Review comprised a Review Outline, a Technical Component, an Economic Component, and a Socioeconomic Component, all of which present information on specific aspects of the program. The Technical Component of the review included data on aspects such as home range data, release and translocation, reproduction and population growth, mortality, dispersal, predation, depredations, and human/wolf interactions. Furthermore, the Technical section of the review incorporated information on management implications, whereby recommendations regarding goals and projections were commented on, and suggestions for improvements presented. Each of the reviews was made available on the Mexican wolf website (http://mexicanwolf.fws.gov/), and written comments were invited. In addition, open meetings were held in New Mexico and Arizona whereby information could be exchanged and questions from the public answered.

The Administrative component of the Five Year review provided an overview of the costs of the project, with estimated costs for the fiscal years 1998 – 2004 provided. The estimated total cost for this period was $7,292,361, and is further broken down into costs for the various agencies involved (U.S. Fish & Wildlife Service 2004b).

Overall, information relating to the Mexican wolf recovery program was relatively easy to obtain, through both peer-reviewed journals and agency reports available through the website. The program appears to be have had clear goals, and have worked towards those goals. In addition, the program has been reviewed and redefined where appropriate on a regular basis. In general, this program seems to be an example of a well-structured and organized recovery attempt, with wolves surviving and reproducing in the wild, while personnel have endeavored to minimize disturbances to local interests.

2.6.3. Red wolf

The red wolf (*Canis rufus*) was previously found in the eastern United States, but wolf numbers declined due to increases in human population, loss of habitat through forest clearing, human settlement and changes in land use, human persecution, and predator control (Paradiso & Nowack 1972). These considerable losses prompted a Red Wolf Recovery Program as early as 1967, which increased in effectiveness following the 1973 Endangered Species Act (Carley 1979). The Recovery Program identified the main threats to the wolves as loss of habitat, loss of young to parasites, persecution by humans, and hybridization with coyotes (Carley 1979).

A captive breeding program was initiated using wolves that had been removed from the wild to prevent the continued reduction in numbers and increasing occurrences of interbreeding with coyotes (U.S. Fish & Wildlife Service 1990, Waddell 1996,). The aims of this breeding colony were to certify the genetic purity of wild-caught wolves, to increase the number of genetically pure red wolves in captivity, and to maintain a continuing red wolf gene pool for re-establishment of the species in the wild and for distribution to selected zoos (U.S. Fish & Wildlife Service 1984).

Following the successful breeding of the wolves in captivity (Waddell 1996), a reintroduction was planned at a site on the border of Kentucky and Tennessee (Phillips & Parker 1988). However, this reintroduction never took place, due to opposition from both local residents and hunters who felt that the presence of the wolves would cause livestock depredation and hunting restrictions, and from environmental and conservation groups who felt the wolves would not receive adequate protection if released at this site (Cohn 1987, Phillips & Parker 1988, Kidder 1992). This opposition was felt to be a direct result of a lack of communication by the local U.S. Fish & Wildlife Service with residents and concerned groups (Moore & Smith 1991).

In 1984, a 47,000 ha piece of land in North Carolina known as the Alligator River National Wildlife Refuge (ARNWR), was donated to the U.S. Fish & Wildlife service. The USFWS and Red Wolf Project personnel worked closely with local people to ensure that the reintroduction plan took into account public concerns (Moore & Smith 1991). The reintroduced population was designated "experimental nonessential" which meant greater flexibility in management procedures to deal with problems as they arose (Parker & Phillips 1991). This helped greatly in obtaining local support for the reintroduction (Moore & Smith 1991).

From 1987 to 1996, captive born red wolves were released at two sites in North Carolina, initially only at the ARNWR and, beginning in 1991 at a site in the Great Smoky Mountains National Park (GSMNP) in the southern Appalachians. In the ARNWR 69 captive-bred wolves have been released and over 96 pups born in the wild, while in the GSMNP 37 wolves have been released and 24 pubs born. There are also three island release sites located in South Caroline, Florida and Mississippi, which were used to give the wolves wild experience (i.e., acclimation to wild conditions) prior to being released on the mainland (Waddell 1996).

The ongoing success of this project, following an initial shaky start, is an example of the importance of public support, especially when planning to reintroduce carnivores. The reintroduction of the red wolf saw the first carnivore species to be returned to the wild after local extinction (Phillips 1990), generating widespread interest in the program.

2.6.4. Canada Lynx

Colorado was the historical southernmost limit of the Canada lynx's range, where they were found in the higher elevations however; they were extirpated or reduced to a small number of animals. Consequently, lynx were listed as state endangered in 1976 and federally endangered in 2000. Several investigations into the status of lynx in Colorado failed to provide any evidence of existence therefore, due to the lack of existing animals and the distance to the next population, the Colorado Division of Wildlife (CDOW) initiated a reintroduction program in 1999 (Shenk 2002).

The goals of the reintroduction program included developing successful release protocols, survival of lynx in the wild, the development of site fidelity, the onset of breeding, reproduction, recruitment, and reproduction exceeding annual mortality.

Site selection for five potential reintroduction sites were assessed on six criteria: relative snowshoe hare (*Lupus americanus*) densities, road density, size of area, juxtaposition of habitats within the area, historical records of lynx observations, and public issues. As a result of this selection process, sites within the San Juan Mountains of southwestern Colorado were chosen as the release areas. Within this area, release sites were situated at the Rio Grande Reservoir, and at 3 sites west of the Continental Divide, based on ownership of the land and site accessibility (Shenk 2001).

During 1999-2000, 96 lynx were released at the selected sites. Release animals were obtained from Alaska and Canada (Shenk 2002), age, sex and body condition were recorded prior to release (Shenk 2001) however, it is unclear whether animals were DNA sampled to provide genotypes for founder information. Various release protocols were implemented, Protocol 1, females were released immediately after veterinary inspection, but males were retained for a few weeks while the females established territories. Once territories had been defined, males were released nearby. Under this protocol, four lynx were released but had poor survival. Protocol 2 comprised holding nine lynx for several weeks in a facility in Colorado until they had sufficient weight gain, but a starvation death still occurred following release. Protocol 3 was developed in response to this death, and consisted of implementing Protocol 2 after May 1 to ensure adequate prey abundance. Protocols 3P and 3P? were the same as Protocol 3 but released animals comprised only females that were known to be pregnant and those that were possibly pregnant, respectively. Post-release monitoring of these individuals led to an additional 55 lynx being released in 2000 under Protocols 2 and 3 with the modifications that animals were held until at least April 1 and releasing pregnant lynx was avoided (Shenk 2001). In 2003 and 2004, 33 and 37 lynx were released respectively (Colorado Division of Wildlife 2004b). An additional 40-50 lynx releases were planned for 2005 (Colorado Division of Wildlife 2004a).

Released lynx were monitored using aerial, ground and satellite radio-tracking. The 41 lynx released in 1999 and four of the lynx released in 2000 were collared with VHF collars. The remaining 51 lynx released in 2000 were fitted with dual satellite/VHF collars. Information regarding collar types and numbers was not available for the 2003/2004 releases. The Colorado Division of Wildlife update for February 2005 states that of the 166 lynx released from 1999-2004, 62 known mortalities have occurred. Of these, the majority occurred during the early stages of the program: 26 in 1999, 24 from the 2000, 4 from 2003, and 7 from 2004. Lynx have been found to be reproducing successfully in the wild. In May of 2003, the first wild-born lynx kittens were documented at the reintroduction site (Colorado Division of Wildlife 2003a), and over 2003-2004 a total of 52 kittens have been recorded (Colorado Division of Wildlife 2004a).

High levels of mortality at the start of the project appear to have been successfully reduced due to alteration of release strategies. Factors limiting success seem to be restricted to the continuing availability of release animals from Canada, where population numbers are currently declining due to a cyclical drop in snowshoe hares (Colorado Division of Wildlife 2004a). Successes of the program include developing effective release strategies, survival of release animals, site fidelity, and reproduction. Kittens born in the wild have been recorded as surviving their first winter, but as yet, none are old enough to have reached maturity and reproduced. The program goal is for the number of kittens maturing and reproducing to exceed overall mortality rates (Colorado Division of Wildlife 2004b).

Organization and permitting information were not detailed in the literature. However, the program appears to have been primarily executed by the Colorado Division of Wildlife. Prior to release lynx were held at the Frisco Creek Wildlife Hospital and Rehabilitation Centre, which was privately owned. Following the death of one the owners, the CDOW purchased the facility for continuing use with the lynx reintroduction program (Colorado Division of Wildlife 2004b).

Funding for the lynx reintroduction program in 1999/2000 was obtained from Vail Associates, the Turner Foundation, and the Colorado Division of Wildlife (Shenk 2002). Further funding for the releases from 2003 onwards was obtained from the Colorado Wildlife Heritage Foundation who commissioned $500,000 over 2003-2004. The program was predicted to cost $2 million over 2003-2005, and the remaining funding was to come from Great Outdoors Colorado and the Colorado Division of Wildlife Non-Game Check-off fund (Colorado Division of Wildlife 2003c).

This program came under heavy criticism during early stages of releases due to the death of several animals from starvation (e.g., Bekoff 1999). However, recent CDOW reports suggest that adaptive measures towards release protocols, and increased levels of survival and reproduction may result in a self-sustaining lynx population.

2.6.5. Channel Island Fox

The island fox (*Urocyon cinereoargenteus*) is endemic to the California Channel Islands (Parker 2002), and is a smaller form of the mainland gray fox (Goldstein et al.. 1999). Currently, six subspecies of island fox (*Urocyon littoralis*) are recognized, one on each of the six largest Channel Islands. On all but San Nicolas, island fox populations are in varying stages of decline (Roemer et al. 2004). Reasons for decline include an outbreak of canine distemper (Santa Catalina), predation (San Miguel, Santa Rosa, and Santa Cruz), and possibly as a result of management actions aimed at protecting the San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*; Roemer et al. 2004). The subspecies on San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina were listed as Federally Endangered in 2004 in response to a decline of as much as 95% since 1994 (Coonan 2003). As a result of reduced population sizes, island foxes have been subject to captive breeding and reintroduction programs on all four islands.

An *ad hoc* working group was formed to promote island fox recovery. This group consisted of individuals from the Channel Islands National Park Service, the Institute for Wildlife Studies, the Nature Conservancy, the United States Department of the Navy, the University of California Los Angeles, New Mexico State University and various museums and zoological institutions (Parker 2002). In the past, this group was responsible for promoting and implementing strategies for island fox restoration, although in a purely advisory capacity.

Island fox populations are managed by various agencies on the differing islands. The National Park Service is largely responsible for the northern Channel Islands of San Miguel, Santa Rosa, and Santa Cruz, with the assistance of The Nature Conservancy for Santa Cruz. The Catalina Island Conservancy is principally responsible for recovery on Santa Catalina, whereas the United States Navy is responsible for San Clemente and San Nicholas. While each of the relevant agencies is principally independent, on the four islands where the subspecies are federally listed as endangered they are required to consult with both the U.S. Fish and Wildlife Service, and the California Department of Fish and Game. In 2004 the Island Fox Integrated Recovery Team was formed, comprising subject Expertise Groups to evaluate and make recommendations, and a Recovery Coordination Group to oversee the recovery strategy and make decisions based on recommendations from the Expertise Groups. However, like the working group, this group also exists in an advisory capacity, and each of the managing entities need not abide by the group's recommendations.

Continuing threats to island fox survival requiring resolution to facilitate island fox recovery were identified for each island. On the northern islands of Santa Rosa, San Miguel, and Santa Cruz, predation by golden eagles (*Aquila chrysaetos*) has been identified as the primary mortality factor (Roemer et al. 2004), whereas on Santa Catalina, San Clemente, and San Nicolas, mortality caused by vehicles is a significantly high factor (Roemer et al. 2004). Canine disease such as distemper poses a significant threat to all island fox populations, and thus, requires control (Coonan 2003).

To counter the decline in populations, captive breeding was initiated with the goal of safeguarding the remaining foxes on each island, and aiding the recovery of the subspecies through augmentation of wild populations (Coonan 2003). Localized captive breeding has been in effect since 1999 on Santa Rosa, since 2000 on Santa Rosa and Santa Catalina, and since 2002 on Santa Cruz (Coonan 2003, Schmidt et al. 2004). In 1999, four U.S. mainland zoological institutions (three in California and one in Utah) were provided with foxes from San Clemente for captive breeding (Parker 2002).

On the three northern islands, captive breeding protocols were standardized across the islands by the National Park Service. Enclosure design and husbandry protocols were designed in line with American Zoological Association recommendations, and are grouped into five categories: facility design and construction, veterinary care, caretaking and handling, breeding strategy, and diet (Coonan et al. 2004). On these three islands, efforts were made to trap all remaining foxes in the wild and bring them into captivity until such time as overt predation risks had been minimized. Enclosure design on Santa Catalina differed from enclosures on the northern islands, with all enclosures built in one area and being of larger design. Diet for the captive foxes on Santa Catalina was developed in association with the San Diego Zoological Society (Schmidt et al.. 2004). Captive foxes on Santa Catalina were obtained from the western end of the island following an outbreak of canine distemper virus that decimated the island fox population east of a narrow isthmus.

Reproductive success has been documented within each of these facilities. For example, in 2003 10 pups were born to 5 litters on San Miguel, 11 pups to 4 litters on Santa Rosa, and 11 pups to 5 litters on Santa Cruz (Coonan et al. 2004). Sixteen pups were reared at the facility on Santa Catalina in 2003 (Schmidt et al. 2004). Genetic analysis of parentage and relatedness has been utilized in pairing decisions within the captive populations (Coonan et al. 2004). Captive breeding is ongoing on Santa Cruz, San Miguel, and Santa Rosa (Coonan 2003). However, all suitable animals were released from captivity on Santa Catalina in December 2004 and captive breeding ceased (Garcelon pers. comm.).

On Santa Catalina, protocols were adopted to facilitate release site selection in 2001, and maintained throughout 2002 and 2003. The sites had to (1) contain a diverse assemblage of habitat types to provide a variety of food items and shelters, (2) water had to be available year-round, (3) the site had to be an adequate distance from busy roadways to minimize road kill mortalities, and (4) the site must have historically supported a high density of foxes prior to the canine distemper virus outbreak (Schmidt et al.. 2004).

Experimental releases took place on Santa Rosa and Santa Cruz in late 2003/early 2004 to assess fox survivorship with eagles still present on the islands, compare survivorship with wild foxes, test release methods, and on Santa Rosa to begin re-establishing a wild population (Coonan et al. 2004). In late 2004, releases occurred on San Miguel and Santa Rosa (Cypher pers. comm.). Site selection criteria are not described for the northern islands.

Prior to release, foxes were assessed for their physical condition (Schmidt et al. 2004), radio-collared, and vaccinated against canine distemper (Figure 1, Figure 2, Figure 3). Released animals were those that were genetically well represented within the captive populations (Coonan et al. 2004). Foxes were released as either mated pairs (and young), single animals, or as groups of animals that had been socialized for a defined period prior to release (Coonan et al. 2004, Schmidt et al. 2004).

Figure 1. Foxes were captured in the captive breeding facility, and a final health assessment was conducted prior to release.

Figure 2. Each fox was vaccinated against rabies and canine distemper.

Figure 3. Foxes were radio-collared for post-release monitoring.

Foxes were hard released from transport kennels, food was provisioned at feeding stations, and foxes were recaptured at intervals following release to assess their physical condition (Figure 4, Figure 5, Figure 6). Any fox that had lost >20% of their release weight was returned to captivity until sufficient weight was regained.

Figure 4. Animals were transported to the release sites and released from travel crates.

Figure 5. Feeding stations, consisting of baited traps that have been wired open, were set in the release area to provide supplemental food.

Figure 6. Recaptured foxes were weighed to assess weight change since release.

Foxes were monitored using radio-telemetry, initially daily during the first month after release (Schmidt et al. 2004), and at least twice weekly thereafter (Coonan et al. 2004, Schmidt et al. 2004). On Santa Catalina monitoring also has been conducted both from the air and from boats to obtain signals in inaccessible areas (Schmidt et al.. 2004). Foxes with mortality signals were pinpointed, and the carcasses retrieved to determine cause of death. Necropsies were performed at the University of California, Davis.

Coonan et al. (2004) present budgetary details for the fiscal year 2003, along with estimated costs for the fiscal year of 2004. Costs are broken down into categories such as captive breeding, supplies and equipment, and eagle removal. The total costs for the fiscal year 2003 came to $815,806, and predicted costs for 2004 were $1,161,542, with the increase being attributed to increased eagle removal efforts.

While the main goal of the island fox program has been to prevent further decline and assist the overall recovery of the four subspecies, on the northern island the specific reintroduction goals have been experimental in their aims. Eagle predation on Santa Cruz, Santa Rosa, and San Miguel is still extremely high, with over half the foxes released on Santa Cruz killed within several weeks of release (Coonan et al. 2004). Releases on these islands have aimed to determine whether released foxes are capable of surviving in the continuing presence of eagles in numbers sufficient to re-establish the population.

On Santa Catalina, where the island fox population on the eastern side of the isthmus was decimated due to canine distemper virus, reintroductions and translocations have aimed to re-establish foxes in areas previously with high density. The recovery goal for this island was to establish at least 150 foxes on each side of the isthmus (Schmidt et al.. 2004). Limiting factors to the recovery effort on Catalina include the continuing risk of disease such as canine distemper virus, and the loss of genetic variation. The main source of mortality of foxes released in 2001 and 2002 was vehicular, although this appears to have been as prevalent in wild foxes as in released foxes (Schmidt et al.. 2004). Survival of animals released in 2003 was 100%. In late 2004, 28 foxes were released on Santa Catalina. To date, there have been three adult moralities caused by vehicles, and one pup with an unknown cause of mortality (Cypher pers. comm.).

2.6.6. Swift fox

The swift fox is one of the smallest North American canids, (Carbyn 1986) and is a closely related species to the kit fox. Swift and kit fox share many ecological and behavioral traits, and therefore knowledge of swift fox reintroduction and translocation is pertinent to any kit fox relocation plans.

The historical range of the swift fox reflects its association with areas of short to mid-grass prairies common throughout the Great Plains (Egoscue 1979). They were thought to have been widely distributed over an area of 1.6 million km^2 in central North America (Scott-Brown et al.. 1987), from north-eastern New Mexico and northwest Texas to southern Alberta and Saskatchewan in Canada (Johnson 1969, Hall 1981). Historical distribution has mainly been determined from museum and fur-trade records, naturalists and explorers (Sovada & Scheick 1999).

From the early 1800s to the mid 1900s there was a decline in both range and numbers (Carbyn 1995). This decline is attributed to factors stemming from human settlement of the prairie, such as habitat loss due to changes from native grassland to agricultural land; susceptibility to predator control measures aimed at other canids, including trapping, shooting and poisoning (Herrero 1984, Russell & Scotter 1984); an increase in intraspecific competition with other canids, in particular coyotes and red fox; and stochastic factors such as disease and climate change having an impact on reduced population sizes (FaunaWest 1991, Carbyn et al. 1994, Carbyn 1995).

The decline in numbers led to the swift fox being considered as potentially endangered in both Canada and the US. In 1978 it was classed as extirpated in Canada (Committee on the Status of Endangered Wildlife in Canada 1978). By 1995 it was also classed as extirpated from over 90% of its historic range in the U.S. and listed as a Candidate 1 species (listing is warranted but precluded due to potential effect of protection on grazing leases) under the Endangered Species Act of 1973 (U.S. Federal Register 1995). Swift fox have been subject to several reintroduction programs, two of which are reported here.

Current swift fox distribution in Canada is limited to those areas in which animals were reintroduced, resulting in sub-populations in southern Alberta and Saskatchewan. The efforts of this reintroduction led to a downlisting of swift fox classification in Canada from Extirpated to Endangered in 1998 (Committee on the Status of Endangered Wildlife in Canada 1998). A survey conducted in 1999 indicated population stability (Moehrenslager 1999). A survey of the Alberta/Saskatchewan/Montana border resulted in a population estimate of 656 foxes around the release site areas in Canada, and a total of 877 foxes in the Alberta/Saskatchewan/Montana area forming a loosely connected population (Moehrenslager & Moehrenslager 2001).

Sightings of swift fox were reported at various locations in the U.S. in the 1950's, and have gradually become more frequent (Carbyn et al. 1994). Population status varies from north to south, with more fox sightings in the southern states such as Wyoming, New Mexico, Texas, Kansas and Colorado (Scott-Brown et al.. 1987). This re-establishment in some parts of their range has led to the swift fox being removed as a candidate for protection under the Endangered Species Act (U.S. Federal Register 2001).

Several reintroduction and translocation programs exist for swift fox, and are listed in chronological order: the Canadian Wildlife Service and Cochrane Ecological Institute (CEI) reintroduction program in Alberta and Saskatchewan; the Blackfeet Tribal Lands/Defenders of Wildlife reintroduction in Montana; the Turner Endangered Species Fund reintroductions at Bad River Ranch, South Dakota; the National Park Service reintroductions in Badlands National Park, South Dakota; and the recently begun Lower Brule Sioux Tribe reintroductions in South Dakota. The Canadian and Blackfeet reintroduction programs are both complete, having ended in 1997 and 2002, respectively. Both of these programs used captive foxes obtained from the CEI, with additional wild translocated foxes used to supplement the Canadian program.

Captive-bred swift fox were maintained at the CEI, situated in the foothills of the Rocky Mountains in Alberta within their historical range. Enclosure design consisted of a wire-mesh fence partially sunk into the ground to obstruct digging and with 'chicken-wire' reinforcements attached to the lower half of the fencing to prevent small kits from passing though the wire mesh. An overhang was built into the top of the fence to prevent foxes climbing out and coyotes climbing in. Visual contact between adjacent enclosures was restricted using large plywood boards attached to the sides and back of the enclosure. Restricted visual contact was thought to increase breeding success (Smeeton pers. com.). The front portion of the fence was not visually constrained and therefore limited visual contact was possible between foxes in different groups of enclosures. Olfactory and vocal communications were not restricted.

Foxes were fed a daily diet of horsemeat, day old chicks when available, and a supplement of commercial dog food in biscuit form. On occasion the foxes were fed live-prey when available. Mesh size of the enclosure fence allowed the entrance of small mammals such as meadow voles (*Microtus pennsylvanicus*), long-tailed voles (*Microtus longicaudus*) and pygmy shrews (*Sorex hoyi*), and the enclosures were not roofed, allowing entrance to birds, particularly magpies. Captive swift fox are successful in exploiting these opportunistic food sources (Bremner 1997).

The young of the year were primarily the foxes released each year. This was occasionally supplemented with yearlings or two-year olds, which had not bred with the mate selected for them within the breeding colony, and which were too closely related to breed with remaining unpaired foxes. The kits emerged from the den during April or May, and remained in the family group until the end of August, at which point they were either released or removed to a new single-pair enclosure with a potential mate selected based on the historical studbook. Animals to be released were selected on the basis of sex and health. Foxes underwent no formal program of pre-release training, and consequently adeptness at survival skills such as predator recognition and avoidance and hunting ability were not criteria considered in selecting individuals for release (Bremner 2002).

Throughout the summer young-of-the-year in the captive colony were given a health check and vaccinated against canine distemper by a Department of Agriculture veterinarian. During the second of these visits, animals were tattooed in the ear for identification (Figure 7), and those foxes selected for release were given export permit health certification. During the Canadian reintroduction program, but not the Blackfeet program, foxes also were given rabies vaccines (Bremner 2002).

Figure 7. Swift fox tattooed in left ear for individual identification. Ear shows dye spread out and will wear off to show only unique number and figure combination.

2.6.6.1. Canadian reintroduction program

In 1978, a reintroduction program of captive-bred swift fox was initiated by the Canadian Wildlife Service and the CEI (Herrero et al. 1986). Over several years the program was joined by a number of federal and provincial government, non-government, and academic groups (Carbyn et al. 1994). The first reintroductions took place in 1983 and continued until 1997 under the guidance of a Recovery Team (Breitenmoser et al. 2001). During this 14-year period, 942 foxes were released (Breitenmoser et al. 2001) at two different sites in Alberta and Saskatchewan. A census conducted in 1996-1997 found evidence of foxes at a total of 25 townships, while a repeat census of the same sites in 200-2001 located foxes at 51 townships. In addition, foxes were found at 25 townships in an area previously unsurveyed (Moehrenslager & Moehrenslager 2001).

This long-running program provided an opportunity to test various methods of release systems (FaunaWest 1991). Initial reintroductions used soft releases, whereby the animals were placed in a holding pen at the release site, usually over winter, and then released in spring following a period of acclimatization. This was later changed to a hard release system where animals were transported to the reintroduction site, and released from their transportation kennels with 24 hours of arrival. A combination of systems was finally favored whereby animals were released within 24 hours from transportation kennels, but were supplied with a Portable Protective Shelter (PPS, Figure 8), thus providing them with initial shelter and protection from predators (Smeeton & Weagle 2000), and a point of reference for the fox to return to while making dispersal forays. In addition, the time of releases was planned to correspond both with pup dispersal in natural populations and with the abundance of important prey species such as grasshoppers.

Figure 8. Example of a Portable Protective Shelter (PPS) at the Blackfeet Indian Reservation release site.

Of the total number of foxes released during the Canadian Reintroduction Program, 91 (ca. 10%) were wild foxes translocated from Colorado and Wyoming. All remaining foxes were captive bred at the CEI (Smeeton & Weagle 2000).

2.6.6.2. Blackfeet reintroduction program – Montana, USA

Following the conclusion of the Canadian Reintroduction Program in 1997, a reintroduction agreement was reached between the Blackfeet Fish & Wildlife Department of the Blackfeet Indian Tribe, the U.S. based conservation charity Defenders of Wildlife (DOW), and the CEI, (Johnson 1999) to attempt to establish a population of swift fox on an area of the Blackfeet Reservation in northern Montana. Swift fox were once common on the eastern plains of Montana (Johnson 1969) with many sightings in the area of the Blackfeet Reservation (Bailey & Bailey 1918). Following a reduction in numbers, swift fox were declared extirpated in Montana in 1969 (Hoffman et al.. 1969). However, sightings increased towards the end of the Canadian reintroduction program (Knowles 1998, Knowles et al.. 1998), with foxes in the northern portion of the state thought to be dispersers from the Canadian Reintroduction Program (Carbyn & Killaby 1989). The Blackfeet Reservation contains one of Montana's best and most extensive areas of grassland, consisting of 1,620,000 acres of grass ridges extending east from the Front Range base of the Rockies (Knowles 1998). The combination of the expanse of prairie, historical records of foxes, recent sightings, and local enthusiasm made it a key site for swift fox reintroduction.

The aim of reintroduction of swift fox onto Blackfeet Tribal Lands in Montana was to establish a second population with the objective of developing metapopulation function, thereby reducing the risk of local extinction in other areas (Knowles 1998). It was hoped that by creating several local populations of swift fox in Montana, which were functionally linked through recolonization by dispersing individuals, risk of local extinctions would decline. Two pre-release surveys of the habitat were conducted (one sponsored by CEI and one by DOW), including details of habitat types, small mammal abundance and species, and presence of other species including predators (Cochrane Ecological Institute 1998). The tribal-owned release site consisted of approximately 20,000 acres of grassland habitat, surrounded on the east and northeast by agricultural land (Knowles 1998). There are two rivers within the vicinity of the site; Badger Creek, which borders the release site, and Two Medicine River, which transects the site. Habitat types included upland short and mid-grass prairie, river benches, coulee drainages, river bottom floodplains bordered with cottonwood riparian habitat, and 1,000-acre parcels of Conservation Reserve Program (CRP) sites. Specific release sites were selected based on location, vegetation, prey availability, and den availability (Knowles 1998).

An evaluation of small mammal populations determined the presence of key prey species such as Richardson's ground squirrels (*Spermophilus richardsonii*), deer mice (*Peromyscus maniculatus*), and northern grasshopper mice (*Onychomys leucogaster*) (Carpenter 1998, Knowles 1998). Insects, especially grasshoppers, were abundant in the summer months, and were an important supplement to the small mammal prey base of the swift fox. Other wildlife regularly observed within the release site area included potential competitors such as badger (*Taxidea taxus*) and red fox (*Vulpes vulpes*), predators such as coyote (*Canis latrans*), red tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), prairie falcon (*Falco mexicanus*), great horned owl (*Bubo virginianus*), Swainsons hawk (*Buteo swainsoni*), and golden eagle (*Aquila chrysaetos*). There were also occasional sightings of elk (*Cervus elaphus*), mountain lion (*Felis concolor*), and occasional signs of black bear (*Ursus americanus*), grizzly bear (*Ursus arctos horribilis*), wolf (*Canis lupus*), porcupine (*Erethizon dorsatum*), beaver (*Castor canadenis*) and white-tailed deer (*Odocoileus virginianus*) (Bremner 2002).

Swift fox are not listed by CITES, thus no CITES permits were required. However, release permits for this reintroduction were required from both Canadian and U.S. sources. The Government of Alberta, Environment Protection provided a Permit to Export (Wildlife), allowing the foxes to be moved from the CEI through Alberta to the U.S. border. The State of Montana, Department of Livestock provided an Entry (import) Permit to bring the foxes into the U.S. This entry permit was also required for the Agriculture Canada health inspection that was done prior to moving the animals and described the vaccine protocol to be followed. No permit was necessary from the U.S. Fish and Wildlife Service as swift fox were not Federally listed, but a physical examination of the foxes by a Federal Wildlife Inspector at the border was required (CEI 1998). In addition, a letter granting permission to release foxes on to the Blackfeet Reservation was obtained from the Blackfeet Tribal Council.

Funding for the reintroduction and the captive breeding colony was provided by DOW, with smaller contributions from private and corporate donors going towards maintaining the captive breeding colony (Cochrane Ecological Institute 1998). Both DOW and the Blackfeet Fish and Game Department provided funding for monitoring the foxes following release (Bremner 2002).

The release strategy utilized techniques developed during the Canadian reintroduction program. Young of the year were transported from the captive breeding facility in late summer, to correspond with dispersal in the wild and high densities of grasshoppers. Animals were transported from the CEI to the release site during the day, and held overnight at their specific release location in transportation kennels spread around a PPS. During this period they were provided with food and water. At dawn the following morning the transportation kennels were opened and the foxes allowed to emerge in their own time (Figure 9). Additional food was placed inside the PPS. Food was placed in the PPS for a period of several days following release if there were indications that foxes were utilizing the shelters.

In 1998 thirty foxes were released. Foxes were not radio-collared prior to release, therefore monitoring was limited to spotlighting and sign (scat and tracks) surveys. In 1999 8 of 15 released foxes were radio-collared, and in 2000 this was increased to 16 of 31 released individuals (Bremner 2002). Data regarding annual numbers of released and collared animals for 2001 and 2002 were not available.

The first release of swift fox onto Blackfeet land took place in 1998, with the release of 30 juvenile foxes. From 1998 through 2002, a total of 117 foxes were released comprising captive-bred adult and juvenile foxes. There is evidence that foxes are surviving and reproducing both on the release site and in surrounding areas (Johnson 1999, Bremner 2002, Bremner-Harrison 2004). Results from a wider census are pending. In addition, the number of natal dens found per year has increased (Johnson pers. com.). As a result of the two swift fox reintroduction programs, the Swift Fox Conservation

Team compiled a set of reintroduction guidelines, to ensure that "reintroduction projects are conducted in a scientifically valid manner, and that such projects support the long-term needs of the species" (Swift Fox Conservation Team 2000). These guidelines will be discussed in the 'Guidelines and Recommendations' section of this report.

Figure 9. Swift fox transport kennels at a PPS release site.

2.6.7. San Joaquin kit fox

The San Joaquin kit fox is a subspecies of the arid land kit fox that historically occurred in the San Joaquin, Salinas, and Cuyama Valleys of central California (Cypher et al. 2001). San Joaquin kit fox populations have been significantly reduced throughout their historic range in central California, primarily due to profound habitat loss and degradation. Much of the habitat within their former range was displaced by agricultural, industrial, and urban development (U.S. Fish and Wildlife Service 1998b).

As a result of this decline, San Joaquin kit foxes are listed as Federally Endangered and California Threatened. Kit foxes persist in a meta-population of 3 core populations and several satellite populations of varying size (U.S. Fish and Wildlife 1998b). The Department of Energy's Naval Petroleum Reserves #1 and #2 (NPR1 & NPR2) in California (purchased by Occidental Petroleum in 1998) each contain large areas of suitable kit fox habitat (Cypher & Scrivner 1992). However, kit fox numbers within NPR1 exhibited a substantial decline (from 165 to 19) during the period from 1981 to 1990 (EG & G Energy Measurements, Inc. 1992, reported in Scrivner et al. 1993). As a result of this decline, from 1988 to 1990 San Joaquin kit foxes were relocated to NPR1. Details of this project are provided in a report by Scrivner et al. (1993). The information that is discussed below was obtained from this report.

Prior to the start of the relocation project, NPR1 was assessed for den availability, fox abundance, predator and prey abundance. However, predator and prey surveys were not conducted in the immediate vicinity of the acclimatization pen sites. A total of 42 foxes were relocated to acclimatization pens dispersed around NPR1 (Figure 10): 13 foxes were relocated in 1988/9 for release in early 1989; three of which were pregnant, and 28 foxes were relocated in 1989 for release in 1990. Foxes brought into the pens were obtained from private properties under development in Bakersfield, and from NPR2 (Table 2). The report does not state whether the aim was to trap any available foxes, or to target a specific age (e.g., adult, juvenile). Upon placement into pens, a veterinarian gave all relocated foxes a health check and blood samples were taken to check for disease. The pens included artificial dens for shelter, either in the form of a plastic den box or PVC piping (Figure 11).

Relocated foxes released in 1989 and 1990 were maintained in captivity for an average of 131 days and 307 days, respectively, prior to release. During this period the foxes were fed a diet of canned cat food, dry cat food, and a commercial carnivore food. In addition, the diet was supplemented with domestic rabbits, cottontails, and jackrabbits. Prior to the 1989 release live domestic rabbits were provided five times during the two-week period before release. Foxes released in 1990 were provisioned with live domestic rabbits approximately every two weeks while held in captivity.

Following the escape of two foxes during their first night in captivity, foxes were radio-collared while in the pens to allow any escapees to be located. New radio-collars were placed on the foxes a few days before release. At this time, weights and measurements of each fox were taken. In 1990, foxes were vaccinated prior to release to prevent internal parasites. The releases utilized the soft release method whereby foxes were held in pens at the release site over fall and winter, and then released in the spring when lagomorph densities were assumed to be highest. The pens were opened in 1989 by extending a four-foot length of 6-inch PVC pipe through the pen walls. In 1990 a hole was cut in the pen doors. Foxes were allowed to exit the pens at their own rate. Foxes were released from only a few pens at a time, and releases were spaced over several weeks.

In 1989, 13 foxes were released comprising the 12 remaining relocated foxes plus one pup born in captivity. Two females relocated to the pens had escaped through a gap between the wall and floor on their first night in captivity. Another female escaped but was re-trapped approximately 6 weeks later and maintained in captivity until the 1989 releases. Only two of the three females that were pregnant at the time of capture produced pups. One of the remaining two females produced more than two pups, but only one survived, the second female produced three pups, all of which were either born dead or died shortly after birth. No further details are provided regarding the cause of death of the pups, however it is likely that relocating the pregnant females into captivity and pairing them with males that may not have been their mates so close to parturition directly contributed to the death of the pups either through increased stressed levels or possibly male infanticide although this has not been documented in kit foxes.

In 1990, 28 of the 29 relocated foxes were released; one relocated male died due to edema and necrosis of the brain and internal hemorrhaging while in captivity. In addition, 10 pups successfully born and raised in captivity were released in 1990, bringing the 1990 release to 38 foxes. An additional 15 pups were observed in the pens but not successfully reared, and a further two pairs had pups that were heard but not seen or reared. Overall, 53 foxes were released during 1989-1990.

Figure 10. Acclimatization pens at NPR1.

Table 2. Demographics of foxes captured for relocation

	Source Population	Juvenile Male	Juvenile Female	Adult Male	Adult Female
1989 release	Bakersfield	1	3	3	3
	NPR2	1	2	0	0
1990 release	Bakersfield	3	4	3	3
	NPR2	9	7	0	0

Figure 11. PVC piping was provided within the pens for shelter.

Foxes were monitored using radio-telemetry both during and after release. Data were collected on movements and survival. Decreasing amounts of dry cat food were provided in the pens for approximately one month after the pens were opened, and any sign of visits by foxes was recorded. On average foxes were last located 122 days after release. Of the 40 relocated and released foxes, data were collected until April 1992. Thirty-six of these foxes died within an average of 96 days, and 3 foxes were declared missing after an average of 232 days. Only one of the 40 was recorded as being alive by April 1992. The majority of the dead foxes were recovered either on or within 2 miles of either NPR1 or NPR2, and most of these were on or near NPR1. Of the 11 pups born in captivity and released, all died within 17 days of release. Causes of death for both adults and pups were mainly attributed to predation and vehicle strikes, there were several cases of mortality where the cause of death could not be determined due to the recovery of too few body parts.

Released foxes exhibited some evidence of reproduction in the wild. While no pups were observed, the female mate of a male released in 1989 showed evidence of having pupped in 1990. These foxes were again paired during the 1991 breeding season but reproductive status was not determined. A female released in 1989 survived for one breeding season, and was trapped with one pup. Of the foxes released in 1990, four foxes survived through their first breeding season, but no signs of pups were obtained. Two of these foxes survived to a second breeding season, and both foxes reproduced producing six and three pups. It is also important to note that these five surviving foxes had been released into differing types of terrain (level or hilly), but those foxes released in hilly terrain moved into level terrain prior to the breeding season, thus indicating the importance of release site selection.

The evaluation report provides a breakdown of the cost of the relocation program. Overall the program cost a total of $490,639 over four fiscal years. Costs were highest for the two years when foxes were held in captivity: $185,180 in 1989 and $158,161 in 1990, compared to $54,606 in 1988 and $92,692 in 1991. This appears to be due to high labor costs in 1989 and 1990, most likely due to the costs associated with maintaining animals in captivity. Labor costs for the whole project accounted for $364,479 of the total cost, and materials and supplies accounted for the remaining $126,160. Materials and supplies covered the costs of radio-collars, pen materials, fox food, blood analyses, transportation, and charter aircraft monitoring (Scrivner et al. 1993).

Monitoring efforts for the kit fox relocation project appear to have been largely successful, with radio contact being lost for only 3 of 51 monitored individuals. However, of the 51 foxes released, including the pups born in captivity, 47 died, many of them relatively soon after release (e.g., all the pups died within 17 days after release). Thus, the number of animals being monitored at any given time generally was manageable.

While efforts to monitor prey availability during the program are not described, the abundance levels for lagomorphs in the year following the second release (1991) are described as being the lowest since monitoring began. The abundance of small mammals was not assessed during the project, despite being a significant prey base for kit foxes (Koopman et al. 2001).

Scrivner et al. (1993) assessed the success of the relocation project according to several factors including the feasibility of relocating foxes to unoccupied regions of NPR1 and the development of an effective relocation technique (soft-release). Four specific measures of success were defined: finding a source of foxes that can be captured, relocated, and maintained in captivity; having foxes remain in the proximity of the release site; survival through at least one breeding season; and successful pup rearing.

Overall, foxes were successfully captured, relocated, and maintained in captivity prior to release with a minimal amount of escapes or injured foxes. One fox died while in captivity. Thus, this portion of the project was considered successful by the program organizers. Success in relation to foxes remaining in the vicinity of the release site was considered partially successful, with the majority of relocated foxes remaining on or near NPR1. As has been observed in other reintroduction projects, a higher proportion of released animals dispersed both away and farther from the site of origin than among free-ranging counterparts. Reintroduced swift fox and red fox exhibited similar behavior when compared with wild conspecifics (Robertson & Harris 1995, Moehrenslager & Macdonald 2003).

Survival of the released foxes was very low with few remaining alive long enough to reproduce. Survival rates were lower than for free-ranging foxes. As few foxes survived long enough to reproduce, reproductive data are limited, thus making success on this variable difficult to assess. Five of the six surviving foxes paired with five free-ranging foxes, and four of these pairs produced pups in at least one year.

Thus, based on these measures of success, Scrivner et al. (1993) discussed a number of alternatives for future activities, including: (1) deferring relocation activities until a higher prey base was available; (2) changing the timing of the releases; and (3) testing other relocation techniques. However, they ultimately recommended that the relocation effort be discontinued, with the proviso that if lagomorph densities increased and fox numbers showed no sign of increase, then consideration be given to relocating foxes to NPR1 in early fall, and releasing them in late fall.

3. TECHNICAL CONSIDERATIONS FOR KIT FOX TRANSLOCATIONS

3.1. *SITE SELECTION*

A number of important site attributes must be considered when evaluating and selecting sites for potential kit fox relocation. These attributes include habitat type, terrain, prey abundance, competitor and predator abundance, available escape cover, available acreage, land ownership and use, linkage or the ability to create linkage to other areas of habitat, and potential human disturbance. Additionally, the current status of kit foxes on a site must be considered. In particular, if kit foxes currently are not present at a given site, then the reasons for their absence need to identified, and if not done so already, these limiting factors need to be mitigated. The more optimal the site attributes at a reintroduction site, the higher the probability of successfully establishing a kit fox population.

Ideal habitat for San Joaquin kit fox habitat consists of arid and semi-arid regions encompassing desert scrub, chaparral, halophytic and grassland communities (U.S. Fish and Wildlife Service 1998b, List & Cypher 2004). While kit foxes can occur in other habitats, their demographic attributes may be less robust in these habitats, which reduces the probability of success for any relocation effort.

While kit foxes have been recorded in both hilly and level terrain, kit foxes may prefer less rugged terrain due to decreased predation risk (Warrick & Cypher 1998, Cypher et al. 2000). Furthermore, among foxes relocated to the Naval Petroleum Reserves and released in hilly terrain, many rapidly moved down to more level terrain (Scrivner et al. 1993). Movements were not analyzed during the relocation project in connection with slope gradients or vegetation components. Given the preference of kit foxes towards level terrain, it may be advisable to select sites for release comprising mainly level terrain, or with a minimum amount of level ground sufficient to accommodate home ranges for a given number of breeding pairs.

Prey availability needs to be evaluated on all potential reintroduction sites. This is particularly important if the habitat has been altered in any way (e.g., grazed, former agricultural land, restored habitat). If sufficient food is not available, kit foxes are unlikely to remain on a release site, but instead will disperse. The Elk Hills reintroduction effort was conducted during a period when regional prey populations were depressed due to drought, and consequently most of the relocated animals left their release sites (Scrivner et al. 1993). Kangaroo rats and other nocturnal rodents are primary foods for kit foxes with insects and rabbits constituting important secondary foods (Cypher 2003). Thus, assessments should be conducted to ensure that these items (or other suitable foods) are present on a potential release site.

Similarly, the diversity and abundance of potential kit fox competitors and predators also should be evaluated at any potential release site. Coyotes, bobcats and red foxes have been identified as potential predators and competitors of kit foxes (Cypher et al. 2001, Nelson et al. 2007). Kit foxes are able to coexist with these competitors through year-round den use, habitat partitioning, and prey partitioning (White et al. 1995, Cypher & Spencer 1998, Nelson et al. 2007), but these strategies are effective only if dens are readily available, habitat composition is heterogeneous, prey are abundant, and competitors are not inordinately abundant.

The abundance of species that could potentially transmit diseases to kit foxes should be assessed. Diseases of particular concern include rabies, distemper, and parvovirus. Other canids (e.g., coyotes, red foxes, domestic dogs) obviously are potential vectors. Other species of concern in the San Joaquin Valley include striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), bats, and domestic cats. In general, disease historically has not been a significant problem for kit foxes, but an inordinate number of vectors at a given site might be cause for some concern.

Available cover in the form of earthen dens should be assessed at any potential release site. If a site currently is not occupied by kit foxes and has not been for more than a couple years, the probability is high that there will be few suitable dens present. In the absence of regular use, kit fox dens tend to degrade over time and eventually fill in or collapse. Given the dependency of kit foxes on dens for escape cover, daytime resting cover, avoidance of thermal extremes, moisture conservation, and rearing young (Koopman et al. 1998), the presence of dens is critical to the success of any reintroduction effort. Thus, if natural dens are not abundant, artificial dens may need to be installed at the site prior to any fox releases.

The attributes above address critical life history needs of kit foxes. Additional attributes warranting consideration address the prospects for the long-term viability of a kit fox population at a reintroduction site. The amount of suitable habitat is important. Each pair of kit foxes requires ca. 600 ha (1500 ac) in high quality habitat (Nelson et al. 2007). Space requirements can be considerably higher (e.g., over 1000 ha or 2500 ac) in lower quality habitat (Cypher 2003). PVA modeling would provide estimates of the carry-capacity for specific sites but it is proposed that potential reintroduction sites for kit foxes ideally should be of sufficient size to support at least 10 kit fox pairs. Thus, sites should encompass at least 6,000 ha (15,000 ac). This should accommodate the establishment of a sufficient number of kit fox pairs to facilitate appropriate demographic, ecological, and social dynamics.

Any potential reintroduction site should include connectivity to other suitable kit fox habitat. Thus, a reintroduced population could become part of the kit fox metapopulation. Such connectivity would provide dispersal potential for the reintroduced population, and also would facilitate demographic and genetic exchange with other kit fox populations, all of which would contribute to the long-term viability of the new population.

Land ownership and use patterns are other important considerations. Ideally, any potential reintroduction sites would be conserved in perpetuity. Thus, lands owned by natural resource agencies of the Federal government or the State of California and private land conservation organizations (e.g., The Nature Conservancy, Center for Natural Lands Management) would constitute the best candidates. Private lands also have potential as release sites as long as such lands include long-term protections, such as conservation easements. Other private lands also could contribute to kit fox reintroduction efforts through voluntary participation by landowners or through more formal means such as Safe Harbor Agreements. However, due to the uncertain long-term conservation status of such lands, they should be considered as buffers or expansion areas instead of primary release areas.

No use or “conservation” likely is the best land use for potential kit fox reintroduction sites. This is more likely to ensure minimal disturbance and reduce risks from anthropogenic activities. One caveat to this is that grazing can be a compatible, and indeed even a beneficial, land use. Cattle or sheep grazing that is conducted in a careful and responsible manner generally does not adversely impact kit foxes. Such grazing has been conducted for many years on the Carrizo Plain and Lokern area, both of which are core areas for kit foxes. Such grazing also may be beneficial by reducing the cover of non-native plants, particularly grasses. Throughout the San Joaquin Valley, non-native species such as red brome (*Bromus madritensis*), ripgut brome (*Bromus diandrus*), and wild oats (*Avena spp.*) have become established and achieve densities that not only exclude native plants, but also detrimentally affect some rodents (e.g., kangaroo rats) that are important prey for kit foxes (U.S. Fish and Wildlife Service 1998b, Germano et al. 2001). Grazing may reduce the impacts of non-native plants. Certain other land uses (e.g., low density hydrocarbon extraction, Cypher et al. 2000) might be compatible with kit foxes, but would need to be evaluated on a case-by-case basis.

The potential for anthropogenic disturbance on and near potential reintroduction sites also should be assessed. In particular, activities on lands surrounding the release site should be examined. Potential human-related disturbances could include hunting (both formal and informal), the presence of pets, the use of off-highway vehicles, and hikers. Land uses such as residential areas could have a "spillover" effect, with frequent incursions onto the release site by humans and domestic animals. Where there is a high probability of disturbance from land uses on bordering properties, mitigation strategies such as buffer zones or fencing may need to be considered.

Finally, the status of kit foxes at any potential reintroduction site must be considered. If kit foxes are not currently present, then it is imperative to determine the reason or reasons for this absence. Once these reasons are identified, then a determination needs to be made regarding whether these limiting factors can be mitigated through elimination or reduction. Factors such as poor habitat quality, overly rugged terrain, naturally low prey availability, inadequate acreage, or chronic anthropogenic disturbance may have low or no potential for mitigation. In such cases, the site would not be suitable for kit fox reintroduction and should not be considered. Factors that have greater potential for mitigation include habitat quality (and possibly prey availability) that has been reduced by non-native plants, an abundance of competitors, insufficient den abundance, and incompatible land use. These factors could potentially be mitigated given sufficient time and financial resources.

If kit foxes are present, but in low numbers, then 2 issues must be addressed. The first is to determine the factors that are limiting population size at the site. This evaluation is essentially identical to that for identifying the reasons that foxes are not present at a site, as described above. Some limiting factors may be impossible or difficult to mitigate, thereby precluding further consideration of the site for fox releases. In other situations, mitigation of the limiting factors may be possible. A second issue when foxes are currently present on the site is the effects on these foxes caused by introducing additional foxes. If the resident population is low relative to the potential carrying capacity on the site, then translocating additional foxes may help the population increase more rapidly and more quickly achieve a viable size. However, if the resident population is approaching carrying capacity, or is exhibiting strong demographic attributes (e.g., survival reproductive rates), then introducing additional foxes may not significantly benefit the population and potentially could be detrimental by displacing residents, disrupting social dynamics, and increasing competition for space and resources. Such sites are not recommended for further consideration as reintroduction sites.

As discussed previously, a prior kit fox relocation effort was unsuccessful because limiting factors were not adequately identified and considered. In the Elk Hills kit fox relocation, some foxes were released in relatively rugged terrain, and the entire relocation effort was conducted during a time of very low prey availability (Scrivner et al. 1993). These factors significantly compromised the potential for success of this effort, and lessons from this failed relocation attempt should be incorporated into future efforts, particularly site selection and prey/predator abundance.

In situations where mitigation of limiting factors would increase the suitability of the site for reintroduced foxes, such mitigation should be conducted prior to any reintroduction effort with sufficient time allowed to assess mitigation success. Releasing animals prior to such mitigation could result in higher mortality and dispersal rates, both of which would reduce the potential for a successful reintroduction.

3.1.1. Potential sites

At least 2 sites in the San Joaquin Valley currently may constitute acceptable candidates for a kit fox relocation effort. One site is the Allensworth Ecological Reserve and surrounding natural and grazing lands in Tulare County. The other site consists of retired agricultural lands in western Fresno and Kings Counties. These sites are described below.

3.1.1.1. Allensworth

The Allensworth site consists of a mosaic of public and private lands (Figure 12). Anchoring this site is the 2,116-ha (5226-ac) Allensworth Ecological Reserve (AER) in Tulare County. The AER is owned and managed by the California Department of Fish and Game. This reserve was established as a conservation area for various listed species, including kit foxes, Tipton kangaroo rats (*Dipodomys nitratoides nitratoides*), and blunt-nosed leopard lizards (*Gambelia sila*). In close proximity to the AER are the Colonel Allensworth State Park (ca. 400 ha or 1000 ac), Pixley National Wildlife Refuge (ca. 2500 ha or 6200 ac), and various private lands on which the primary land use is cattle grazing. Also, these properties are within 10 km of the Kern National Wildlife Refuge, which is contiguous with other public and private conservation lands.

Habitat types in this area consist primarily of alkali sink scrub, with some saltbush scrub and grasslands. The terrain is almost exclusively flat. Grazing is conducted on parts of Pixley NWR and many private lands in the area. No grazing currently is conducted at the AER or at Colonel Allensworth State Park. Land uses on surrounding properties are primarily agricultural, with some recreational use (e.g., waterfowl hunting). Thus, the potential for anthropogenic disturbance probably is low.

The abundance of prey, competitors, and dens would need to be assessed in this area. The California Department of Fish and Game conducts annual small mammal monitoring at AER and kangaroo rats appear to be relatively abundant (S. Juarez, California Department of Fish and Game, personal communication). The CSUS Endangered Species Recovery Program monitors Tipton kangaroo rats at Pixley NWR, and kangaroo rats (primarily Heermanns kangaroo rats – *Dipodomys heermanni*) are abundant at this location (P. Kelly, ESRP, unpublished data). Other potential prey in the area include other nocturnal rodents, California ground squirrels (*Spermophilus beechyi*), black-tailed jackrabbits (*Lepus californicus*), cottontails (*Sylvilagus audubonii*), and various birds, reptiles, and insects. Coyotes are common in the area, but probably not inordinately so. The availability of existing dens is unknown but is probably low due to the recent absence of kit foxes.

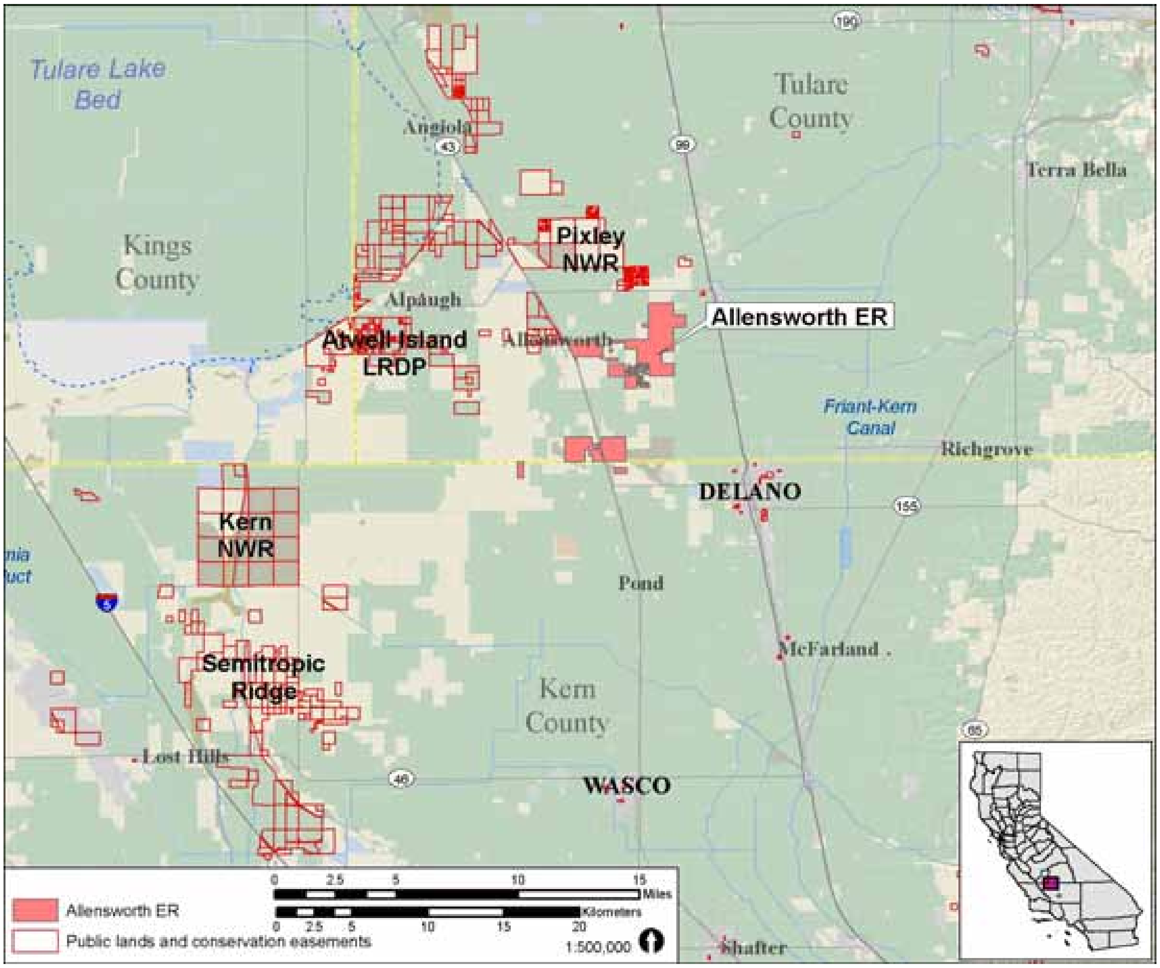

Figure 12. Allensworth Ecological Reserve and nearby public lands.

Kit foxes used to be routinely observed in the area, although densities apparently were relatively low compared to core areas (e.g., Lokern Natural Area, Carrizo Plain National Monument). However, kangaroo rat populations "crashed" in the mid-late 1990s in association with several years of unusually high precipitation levels (Single et al. 1996, Germano et al. 2001). Kit fox abundance also apparently declined during this time, and kit foxes have not been observed in the area for several years (S. Juarez, California Department of Fish and Game, personal communication).

The current absence of kit foxes in the Allensworth area appears to be a result of the catastrophic kangaroo rat decline in the 1990s. Apparently, alternative foods were not sufficiently abundant to sustain kit foxes. Also, there was localized flooding associated with the high precipitation years, and it is unknown whether such flooding may have caused kit foxes to disperse from the area. However, rodent populations, particularly kangaroo rats, appear to have recovered in the region. Connectivity between the Allensworth area and lands currently occupied by kit foxes is not optimal. Kit foxes appear to be relatively abundant about 10 km southwest of Allensworth in the Semitropic Ridge area (Greg Warrick, Center for Natural Lands Management, personal communication). Also, at least 2 vehicle-killed kit foxes were reported from the vicinity of Kern National Wildlife Refuge in 2006 (S. Frazer, U.S. Fish and Wildlife Service, personal communication), which also is within 10 km of Allensworth. However, natural lands between these areas and Allensworth is highly fragmented necessitating kit foxes to cross parcels of agricultural lands, which may be somewhat challenging. Therefore, relocating kit foxes to Allensworth likely would accelerate colonization of the area by kit foxes, and given that the prey base appears to have recovered, there is a reasonable probability that a kit fox population might be re-established in this area.

Suitable dens for kit foxes may not be sufficiently abundant in the Allensworth area due to the recent absence of foxes. However, this deficiency could be mitigated by the installation of artificial dens. Subterranean chambered dens as well as surface escape type dens could be placed throughout the reintroduction area to provide critical cover for kit foxes. (See Release methods section).

3.1.1.2. Retired Agricultural Lands

Large tracts of cultivated lands in western Fresno and Kings Counties are considered "marginal" for agriculture. Cultivation of these lands was facilitated by the Central Valley Project, which significantly enhanced the availability of irrigation water. However, much of this area is relatively low-lying, and consequently, lands are characterized by shallow water tables, saturated soils, poor drainage, high selenium concentrations in ground water and soil, and low plant productivity. The Central Valley Project Improvement Act was enacted in 1992 and authorized the purchase of land and water rights from willing sellers who were receiving water from the Central Valley Project (Ritter & Lair 2007). The result is that over 80,000 ha (200,000 ac) of these marginal lands may be "retired" from cultivation (Figure 13). Although some of this total likely will be converted to uses incompatible for kit foxes, much of it is forecasted to be used for livestock grazing or to be restored to a more natural state, either through active or passive restoration. Thus, these retired lands may present an opportunity for reintroducing kit foxes.

A number of issues and challenges would need to be addressed before a kit fox reintroduction could be attempted in this area. The historic habitat in this area was alkali sink with some saltbush scrub and grasslands. The terrain is almost exclusively flat. However, most of the lands in this area have been under cultivation for an extended period of time; in most cases, this period has spanned decades. Consequently, most lands are highly disturbed and natural communities have essentially been eliminated. Once cultivation is discontinued on these lands, they commonly are quickly overgrown with invasive, non-native plant species. Ecological restoration efforts to date have met with limited success in restoring natural communities (Ritter & Lair 2007). However, such efforts continue, and new strategies may yield more promising results. In particular, managing vegetation structure through grazing or other means may significantly enhance the suitability of retired lands for kit foxes and their prey. Indeed, many of these lands likely will remain in private ownership and probably will be converted to grazing lands, which could benefit kit foxes.

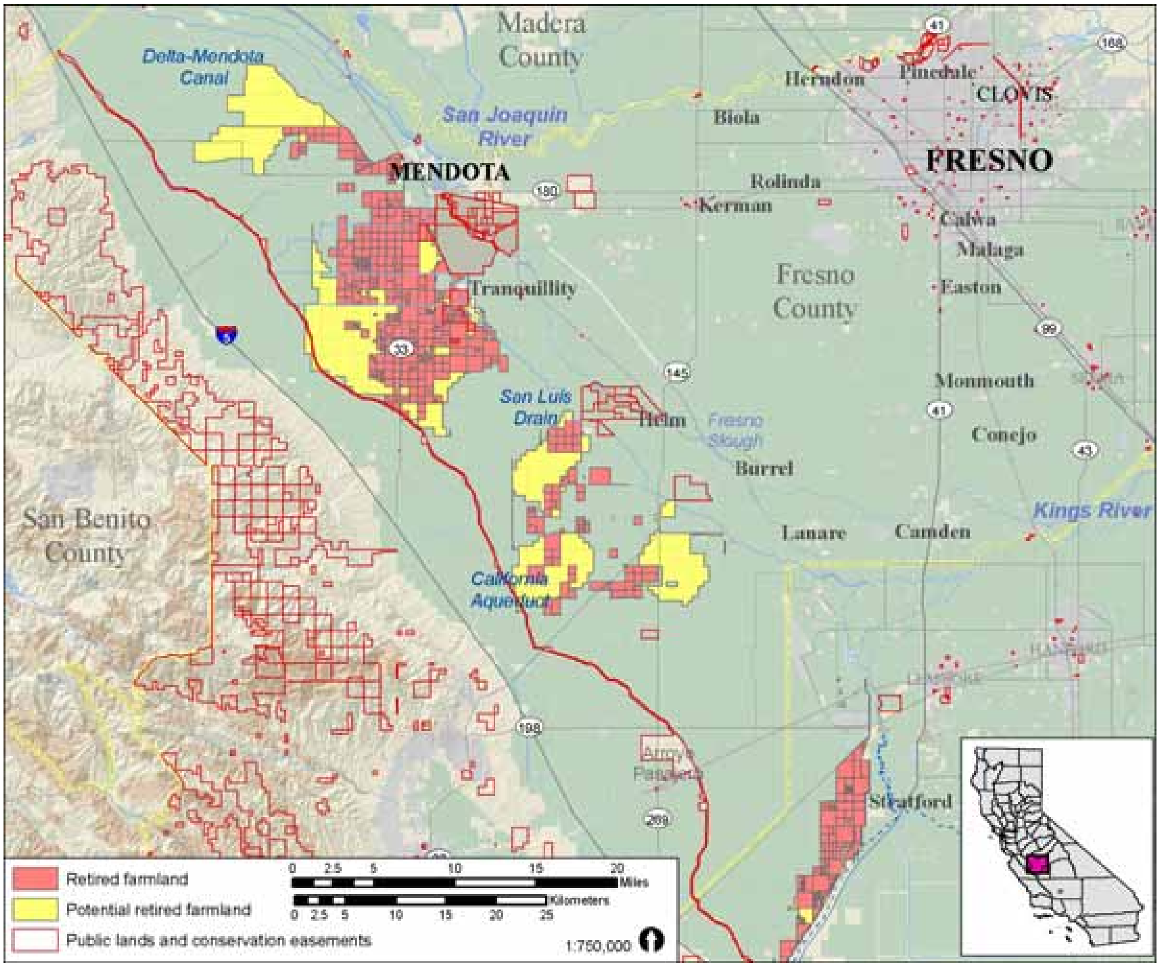

Figure 13. General location of agricultural lands targeted for retirement.

Addressing the profound ecological perturbation on these lands is one significant challenge. Another is land ownership. Under the terms of the 1992 Central Valley Project Improvement Act, some of these lands may be purchased by the Federal government. Although some of these acquired lands will be used to address drainage issues (e.g., converted to evaporation ponds, used for spreading drainage water), others will be restored as habitat. However, as alluded to above, the majority of retired lands will remain in private ownership. Thus, agreements will need to be negotiated with private landowners before kit foxes can be introduced. Such agreements could include conservation agreements, conservation easements, and Safe Harbor Agreements.

Once the challenges above are addressed, then prey and competitor abundance will need to be evaluated. Once cultivation has been discontinued, abundance of rodents, birds, reptiles, and insects likely will increase, although the rate of these increases is unknown. Lands proposed for retirement tend to have high levels of soil selenium, but bio-accumulation of selenium in potential prey for kit foxes was not evident (Interagency Land Retirement Team 2005). Coyotes are currently present in the area, but their relative abundance is unknown. Also, few dens are likely to be present due to past ground disturbance and the current absence of kit foxes. Thus, any reintroduction effort will need to include the installation of artificial dens, preferably on mounds to avoid flooding.

Kit foxes used to occur in this region prior to conversion of the natural communities to agricultural uses. Currently, kit foxes occur in natural habitats approximately 20-50 km to the west. These kit fox populations occur almost exclusively on the west side of Interstate 5. Few if any corridors currently exist between these natural lands and the retirement lands, although corridors could be created in the future, depending upon the patterns of retirement. Thus, reintroduction likely is the most viable strategy for re-establishing kit foxes in this area.

3.2. POTENTIAL SOURCE ANIMALS

As discussed earlier in this report, there are a number of issues to consider when selecting animals for relocation. Paramount among these issues are minimizing impacts to source populations and selecting individual animals with the highest probability for successful relocation.

For any species, it is important not to adversely impact the source population(s) when removing animals for relocation. Potential impacts were discussed earlier in this report. Avoiding such impacts is even more critical when dealing with a rare species, such as the San Joaquin kit fox. Source populations should be relatively large and demographically robust such that the removal of a limited number of individuals for relocation will not adversely affect the population. Kit fox populations that may satisfy these criteria include those in the Carrizo Plain National Monument in eastern San Luis Obispo County, the Lokern Natural Area in western Kern County, and the city of Bakersfield in central Kern County (U.S. Fish and Wildlife Service 1998b, B. Cypher unpublished data). All have relatively large kit fox populations (>100), and all of these populations have exhibited long-term stability and persistence. Thus, a select number of animals likely could be removed without harming these populations.

One caveat is that although these populations are relatively large and stable, at least 2 of them can be quite dynamic. Kit fox populations in natural habitats can fluctuate markedly depending upon environmental conditions. For example, extended drought conditions can cause prey populations to decline, and this can result in a concomitant decline in kit fox abundance (e.g., Cypher et al. 2000). Consequently, removing animals for relocation when abundance is depressed could adversely affect the Carrizo and Lokern populations. The Bakersfield population may not be subject to such fluctuations. Due to factors such as more consistent water availability maintaining prey densities (e.g., from landscape irrigation) and availability of anthropogenic food sources (e.g., trash, pet food), kit fox abundance appears to be relatively consistent in Bakersfield. Equally important, demographic attributes appear to be quite robust. In particular, survival rates are slightly higher and reproductive rates are markedly higher in this population compared to rates in natural habitats (B. Cypher, unpublished data). Consequently, this population may be producing a surplus of animals, and therefore the removal of foxes for relocation is less likely to cause adverse effects.

Once a source population is identified, then individuals must be selected for relocation. Such individuals should conform to established criteria including health, genetic, age, sex, and behavioral suitability. Obviously, only healthy foxes should be used in any relocation effort. Unhealthy animals may die during the relocation, or fail to survive and reproduce after relocation. Also, it would be preferable to use animals that are not closely related. This will ensure that the founding population is genetically diverse, which will help to avoid potential inbreeding effects.

Established kit fox populations generally exhibit a relatively even sex ratio (see Cypher et al. 2000). However, translocated adult female swift fox had lower survival rates than males (Moehrenslager & Macdonald 2003), and therefore it may be advisable to release more females than males until balanced sex ratios are established. Also, juvenile foxes are recommended for translocation. Although adult foxes may be more experienced at avoiding predators and hunting prey, they also may be less adaptable behaviorally and therefore may not fare as well if relocated to a new location. Juvenile foxes of dispersal age may adapt to new situations more readily and therefore may be more suitable for relocation. Translocated juvenile swift foxes dispersed less and showed higher survival and reproductive rates than translocated adults (Moehrenslager & Macdonald 2003). In addition, litter sizes of breeding translocated juveniles were similar to those of resident foxes.

Finally, as with humans, animals exhibit individual behavioral traits, and these could affect their success during relocation. In particular, recent research has found that individuals vary with regards to boldness. Bolder animals may be more likely to explore new habitats and try new foods, but shyer animals may more readily avoid potential threats. Among relocated swift foxes, survival was higher for less bold foxes whereas bolder animals dispersed further and were more susceptible to mortality from predators and vehicles (Bremner 2002, Bremner-Harrison et al. 2004). Among island foxes, bolder animals were more likely to disperse farther and explore new areas (Bremner-Harrison et al. submitted). In an on-going study sponsored by the Central Valley Project Conservation Program, behavioral attributes are being investigated among kit foxes in 2 potential source populations, the Lokern Natural Area and the city of Bakersfield. The objectives of this research include comparing behavioral attributes between the 2 populations, and assessing survival, reproduction, and dispersal among individual foxes relative to their levels of boldness. The results of this study will contribute significantly to selecting kit fox source populations as well as specific individuals for relocation.

3.3. STRATEGIES AND TECHNIQUES

3.3.1. Capture, transportation, and care methods

Prior to any kit fox relocation effort, specific protocols should be developed and approved by all participating parties. Below are some preliminary ideas and recommendations for relocating foxes.

Current methods of capturing San Joaquin kit foxes involve live-trapping and handling with a bag. Wire-mesh box traps (measuring 38 x 38 x 107cm) are baited with meat products. To reduce tooth injuries, each trap contains two rope chew toys, with one attached to each end of the trap. In addition, the traps are covered with a heavy-duty tarpaulin that provides shelter from inclement weather and shade from the sun (Figure 14).

Figure 14. Tomahawk live trap covered with tarpaulin for shade and shelter and showing chewed rope toy.

During the handling procedure, foxes are coaxed from the trap into a denim handling bag that is approximately 75 x 75 cm. Using this method, the animal is manually restrained, which precludes the need for chemical immobilization (and associated risks). The handling bag not only restrains the fox, but also covers its eyes and affords it a sense of security, and most foxes are generally calm while in the bag. During processing, various parts of the fox are exposed to provide access.

During handling, foxes are weighed, sexed, ear-tagged, aged, checked for injuries, and genetically sampled. All foxes initially receive a uniquely numbered metal ear tag. Genetic samples include a 2-mm tissue sample collected with a biopsy punch (Miltex Inc., Pennsylvania , USA) from a pinna and stored in alcohol, and 25-50 hairs with roots stored in a coin envelope. Once handling is completed, the fox can be released at the capture site, or placed in a carrier for transportation (Figure 15, Figure 16, Figure 17, Figure 18, Figure 19, Figure 20).

If juveniles were to be released, it would be preferable for pups to be captured at an early age and marked and sampled. This would allow sufficient time for genetic and disease samples to be screened and for individually marked pups to be behaviorally assessed prior to individual release candidate selection. At the time of first capture it may be helpful to place pup-sized collars onto prospective release candidates to allow for locating them as needed for behavioral observation and recapture. Pup-weight collars are currently being tested on captive kit foxes by CSUS Endangered Species Recovery Program staff.

Figure 15. Trapped foxes are coaxed from the live trap into a handling bag.

Figure 16. Foxes are weighed.

Figure 17. The posterior end of the fox is exposed to sex the individual and check the reproductive status.

Figure 18. Each fox is given an individual ear-tag for identification. Females are tagged in the right ear, males in the left.

Figure 19. A 2mm tissue biopsy sample is taken from the pinna for DNA analysis.

Figure 20. The head and face are exposed to check the teeth for aging purposes and for signs of injury.

Foxes can be transported from capture sites to release sites in hard-plastic portable pet carriers. A carrier sized to transport a cat or small-medium dog would be sufficient for transporting kit foxes. However, if foxes are going to be retained in the carrier for more than about 8 hours, a carrier should be used that is sufficiently large to allow foxes to stand and move around a bit. Water should be offered as the stress of capture, handling, and transportation could result in dehydration. Also, if foxes will be retained in carriers overnight, food should be offered as well. Wet or dry cat or dog food should provide sufficient nutrition for foxes. Carriers with foxes should be placed somewhere protected, quiet, and shaded.

Foxes should be transported in a vehicle that to the extent practical maximizes their comfort and minimizes stress. Foxes should not be subjected to excessive sun, wind, noise, or vibration. Enclosed trucks or vans would work well provided they were sufficiently ventilated. Carriers should be secured such that they do not slide or tip over.

As discussed previously, only healthy foxes should be used in any relocation effort. To this end, it is imperative that a veterinarian be intimately involved in any relocation effort from the initial planning stages through the actual releases of animals on the reintroduction site. Animals can be inspected upon initial capture for injuries and signs of poor health. Foxes in traps should appear alert, in good body condition, and free of injury. Particular caution should be exercised if animals appear lethargic, excessively stressed, thin or gaunt, or appear to have an obvious injury (e.g., a wound or blood is visible, animal is limping, a deformity is obvious).

During handling, foxes should be subjected to a thorough examination by a veterinarian. In addition to checking any external wounds and dental condition, other potential procedures could include checking ears and eyes for abnormalities, examining lungs and heart via stethoscope, drawing a blood sample for analysis of hematological parameters and disease exposure, and collecting a fecal sample to examine parasite loads. Animals potentially could be held in captivity until any necessary laboratory analyses are completed and animals are declared free of health concerns. Although disease generally has not been a significant issue for kit foxes, as a precaution, foxes should be vaccinated against one or more diseases, as was done for reintroduced island foxes (Coonan 2003) and swift foxes (Sovada et al. 2006). In addition, if foxes are already present on the release site, it may be advisable to trap and test individuals for disease prior to any releases to prevent infecting foxes translocated from the source population.

3.3.2. Release methods

Factors to consider when developing strategies for releasing relocated animals include time of year, “hard” release versus “soft”, and acclimation to the release site. The optimal time of year for releasing animals will depend upon which animals are relocated. As discussed previously, juveniles may be optimal because they may be better adapted behaviorally to explore new locations, habitats, and foods. In addition, removing a small number of juveniles from the source population each year for a few years may have less impact on the source population than removing established breeding adults. If such juveniles are selected for relocation, then late summer through fall may be the optimal time to choose as this coincides with the typical dispersal period for kit foxes (Koopman et al. 2000). Carbyn et al. (1994) found that juvenile swift foxes released in the fall had higher survival than those released in the spring.

Release strategies for translocated animals are frequently categorized as “hard” or “soft”. Hard releases entail transporting animals to a release site and liberating them directly into the environment. Soft releases entail placing animals in some sort of protective structure on the release site, and then allowing them to leave of their own free will. In some cases, animals are able to depart from protective structures immediately and in other cases they are prevented from departing pending some “acclimation” period, with such periods ranging from hours to months.

Factors to be considered in determining the more effective release strategy include potential risks (e.g., predators) at the release site, need for food provisioning, and need for recovery after transportation. Relocated animals may be unfamiliar with threats (both type and magnitude), habitat conditions, location of cover, and location of food sources at the release site. This places relocated animals at considerable risk, particularly if hard released. A hard release may be appropriate under some combination of the following conditions: (1) mortality threats are not considered inordinately high, (2) habitat types on the source and release sites are similar, (3) cover is abundant and easily located, (4) food is abundant and easily located, and (5) animals are not inordinately stressed during transport to the release site. Generally, such conditions are not satisfied, although some exceptions may include translocations of large ungulates. In a case involving foxes, the conditions above were met on the island of Santa Catalina resulting in hard releases of both wild and captive-bred island foxes (Coonan 2003). In many cases, and in most involving small carnivores, the conditions are not sufficiently true to justify hard releases. Thus, a soft release strategy is more appropriate. As discussed previously, soft releases involving protective shelters were used for translocated and captive-bred swift foxes, and also for captive-bred black-footed ferrets.

In the case of kit foxes, a soft release strategy would be the most appropriate. Unlike the relocation effort attempted at the Navel Petroleum Reserve, maintaining foxes in captive enclosures is not recommended due to several factors including the increased stress involved for the translocated animals, the potential for attracting predators to a site where regular food provisioning is occurring, and the increased expense associated with captivity. However, coyotes and possibly other predators are likely to be abundant on any release site. Although kit foxes could potentially elude such predators, they primarily do so by seeking cover in dens, but translocated foxes will not be familiar with the locations of dens at release sites. Indeed, as discussed previously, natural dens may be rare or even non-existent at some sites due to the current absence of kit foxes. If foxes are translocated from natural lands, then habitat conditions at release sites might be similar, but also could be different (e.g., saltbush scrub versus alkali sink or grassland). If foxes from urban environments are translocated, then habitat conditions at release sites will certainly be unfamiliar. Although food should be abundant at release sites (a pre-requisite for selecting a release site), such food may be heterogeneously distributed and released foxes will not be familiar with good foraging locations. Finally, potential stress levels of translocated foxes are unknown. Such levels likely will be influenced by the elapsed time from capture to release, and the amount and type of handling animals are subject to during captivity. It is likely that released individuals will be above ground for some period following release performing exploratory behaviors, and thereby exposing themselves to some level of predation risk.

One potential approach is to create refugia for kit foxes at release sites. Such refugia could consist of subterranean artificial dens. Kit foxes readily use such structures (B. Cypher, unpublished data). These dens should include one or more subterranean chambers and at least 2 entrances (Figure 21). A complex of 2-3 dens could be installed in an area approximately 0.4 ha (1 ac) in size. At least one complex should be installed for each pair of foxes released. Translocated foxes could be released into these structures and then the entrances could be blocked to prevent the animals from immediately leaving the dens. This will provide some time for foxes to acclimate to the dens as well as providing time for foxes to recover from stress and anxiety associated with the translocation. The den entrances could be unblocked after sunset when the cover of darkness would provide some protection for foxes. Reintroduced swift foxes in South Dakota were placed in unoccupied earthen dens to both provide immediate shelter as well as to allow a period of adjustment for the foxes (Sovada et al. 2006).

Figure 21. **Example of a multi-chambered artificial den.**

To further provide refuge from larger predators, exclusionary fencing could be constructed around the den complexes. Standard "hog-wire" type fencing with 10- to 15-cm mesh size at the bottom would allow foxes to freely move in and out of the exclosure, but would exclude passage by coyotes. Additionally, surface-style escape dens could be scattered around the release site to afford kit foxes refuge when they are foraging outside of the fenced complexes (Figure 22). Swift fox survival was significantly enhanced by the presence of escape dens (McGee et al. 2006). Finally, supplemental food could be provided within exclosures for several weeks post-release to ensure that kit foxes have adequate nutrition until they become familiar with local foraging areas. "Feeder pipes" elevated off the ground (ca. 30-50 cm to discourage use by rodents) and filled with dry cat or dog food worked well during a supplemental feeding effort conducted at Elk Hills in Kern County during 1988-89 (Warrick et al. 1999, Figure 23). However, caution should be used to ensure that food provisioning does not attract coyotes or other predators

If kit foxes are already present at the release site unoccupied natural dens could be utilized for releases. In order to make locating natural dens easier for released foxes, portable protective structures such as those used in swift fox releases in Montana could be placed over unoccupied dens (Bremner-Harrison et al. 2004). Foxes would be released into these structures for protection, and supplemental food could be provided inside the shelter. The shelter is designed with small entrances to provide refuge from predators for released foxes. Prior to the release effort shelters could be placed over dens within the source population's habitat to allow foxes to associate the structures with refugia.

Figure 22. Example of a surface escape den.

Figure 23. Example of a feeder pipe used for supplemental feeding during the Elk Hills kit fox relocation.

3.4. POST-RELEASE MONITORING

In order to accurately determine the success of the reintroduction program, monitoring should be conducted for some period of time post-release. The goal of this monitoring would be to assess the status and fate of released foxes and to assess the status of the reintroduced population over time.

The status and fate of individual foxes would most effectively be monitored using radio-telemetry. All translocated foxes should be fitted with a radiocollar prior to release. Foxes should be located daily for at least the first six weeks following release, and preferably several months, to ensure that they remain in the reintroduction area. Continued weekly or bi-weekly monitoring would provide information on survival, causes of mortality, reproduction, space use patterns, dispersal movements, locations of new den sites, and activity patterns. Data obtained from radio-tracking will vary depending on the intensity and type of monitoring (Robertson 1994). Locations can be collected to provide spatial data, or individual animals could be located by tracking them to dens or until the fox is observed (Harris et al. 1990). Sightings of radio-tracked foxes also can provide information on reproduction and behavior.

Live-trapping also could be conducted to assess the health status of individual foxes following release. This strategy was employed in the reintroduction of island foxes. Attempts were made to recapture foxes from 1-6 months post-release in order to assess changes in mass (D. Garcelon, personal communication). Foxes exhibiting ≥ 20% loss in mass were returned to captivity until they recovered lost mass. Capture also could be used to assess reproductive status of released foxes and to mark any new foxes. Finally, live-trapping could be used to assess population size via capture of new individuals or mark-recapture techniques.

Population status also could be assessed using non-invasive methods. Population size and recruitment could be assessed through non-invasive genetic sampling. Furthermore, such genetic sampling conducted after an appropriate period of time could be used to determine the genetic composition of the re-established population and help determine whether additional translocations might be beneficial to enhance genetic variability within the population. Genetic monitoring could be conducted using systematic sampling of hair and feces, both collected non-invasively. Such sampling could provide information on gender, survival rates, population density, sex ratios, home range, dispersal, distribution, paternity, and kinship (Kohn & Wayne 1997, Kohn et al. 1999, Ernest et al. 2000). Hair generally provides DNA samples of higher quality than fecal samples, thus providing a more reliable DNA source than fecal DNA. However, fecal samples are easier to collect than hair samples because they require no manipulation of the animal, while the collection of hair samples relies upon enticing an individual to use a hair-sampling device. Behavioral studies of captive swift fox have demonstrated variation between swift foxes in avoiding novel objects (Bremner-Harrison et al. 2004). Therefore, it is likely that not all foxes would enter a hair trap, which may result in sampling only a sub-set of the population.

When obtaining demographic information on a reintroduced population it is critical to gather data from as many individuals as possible to provide an overview of the entire population, thus informing future management decisions. Consequently, it would be advantageous to obtain genetic samples using both hair and fecal collection methods. This would increase the likelihood of obtaining information on as many individuals as possible within the population. Several effective techniques have been developed for such sampling.

A hair sampling method has recently been developed for use with San Joaquin kit foxes that eliminates the potential for contamination of samples through visits by multiple individuals. During developmental tests with both captive and wild San Joaquin kit foxes this system both collected a sufficient sample of hairs and prevented cross-contamination by excluding visits by multiple individuals. In essence, a fox is attracted to a station with bait or a lure, enters the system, a hair sample is collected, and then the fox exits. At the time of exit, the trap is effectively sealed against entry by other animals, thus preventing multiple sampling (Bremner-Harrison et al. 2006).

Confirmed San Joaquin scat samples for DNA analysis have been successfully collected using scent detection dogs (Smith et al. 2003). Dogs trained to locate kit fox scats under field conditions proved to be more effective at finding scats than humans trained in kit fox scat identification. All of the dogs used in this study were 100% accurate in identifying kit fox scats despite the presence of coyotes, skunks and badgers. In addition, the dogs were able to distinguish with 100% accuracy between kit fox scats and scats of sympatric fox species such as red foxes and gray foxes (Smith et al.. 2001; 2003).

One final note, food habit monitoring should be considered to determine what food resources kit foxes are exploiting in reintroduction areas. Such monitoring is easily conducted by collecting and analyzing kit fox scats. Scats can be collected either opportunistically or systematically by biologists on foot. Scats also can be collected using scent detection dogs, as described previously. Scats collected for genetic analyses also can be used for food habitat analyses once the necessary genetic material (external mucous coating) is removed. Food habit analyses can help to gauge adaptation to reintroduction sites by foxes as well as offer insights regarding whether foxes are finding adequate nutrition.

In conclusion, intensive radio-tracking of all released animals is recommended for at least the first year following release. This should comprise obtaining daily locations for the initial post-release period of approximately six weeks as this has been shown to encompass several phases of movements following release described by Moehrenschlager & Macdonald (2003) as acclimation, establishment, and settlement. Live capture should also be considered to assess the condition of released foxes. Genetic monitoring should be conducted for at least 5 years to assess population status and recruitment. In general, monitoring should be conducted until such time as success criteria (see below) are achieved and the re-established population is considered secure (Wallace 2000).

3.5. SUCCESS CRITERIA

As discussed earlier in this report, the overall objective of a relocation program is to produce a viable self-sustaining population (Griffith et al. 1989). Although this is the ultimate goal, it likely will take some number of years to achieve. Therefore, interim goals are useful to gauge progress and help determine whether changes in strategy might be warranted. The following are potential interim goals that could be considered for any kit fox translocation efforts. Demographic targets are based on mean values for a stable kit fox population monitored over a 15-year period in the Elk Hills area located in the southwestern San Joaquin Valley (Cypher et al. 2000).

1. **Translocation:** No foxes die or incur serious injury during capture, captivity, transport, or release.
2. **Site fidelity:** At least 75% of released foxes do not disperse out of the reintroduction area.
3. **Survival:** At least 40% of released foxes survive for 1 year post-release.
4. **Reproduction**: At least 50% of adult females age 2 years or older successfully produce and rear litters of pups to the point where the litters are observed above ground at natal dens.
5. **Recruitment:** At least 15% of pups survive to age 1 year.
6. **Den use:** Within 1 year post-release, foxes begin creating and using new earthen dens.
7. **Food habits:** Within 2 months post-release, foxes are feeding primarily on natural prey and not relying on supplemental food.

3.5.1. Population structure:

A viable self-sustaining population is produced with adequate levels of genetic variability to allow the population to react to future stochastic events.

Demographic modelling might help to refine some of the demographic targets listed above. Such modelling also might help to define "viable, self-sustaining population." In the absence of such modelling, a potential threshold population goal might be at least 10 breeding pairs of foxes present in each of 3 consecutive years and with these pairs collectively producing at least 5 litters each year.

Modelling might also help determine the number of foxes that should be relocated initially. Again, in the absence of modelling, a reasonable number might be 5-10 pairs of foxes relocated initially, with additional foxes relocated as needed.

Ideally, any reintroduced population would not be isolated, but would have some connectivity to as well as some demographic and genetic exchange with one or more other populations. Thus, demonstrated interchange between the re-established population and other populations should constitute another long-term criterion for success.

3.6. REGULATORY REQUIREMENTS

A variety of permissions and regulatory issues would need to be addressed prior to any relocation effort. These are briefly listed and described below.

3.6.1. Endangered Species Act

San Joaquin kit foxes are Federally listed as Endangered under the Endangered Species Act (ESA). Therefore, any activities that could potentially cause harm to the species must be reviewed by the U.S. Fish and Wildlife Service, and then such activities must be authorized through a formal permit. Such permits are referred to as "recovery permits" and are authorized under section 10(a)(1)(A) of the ESA. This permit will list acceptable methods and procedures, and will also establish a "take" limit in the event of any fox fatalities. Such permits are also published in the Federal Register and are subject to public review and comment prior to being issued.

3.6.2. California Endangered Species Act

San Joaquin foxes are listed as California Threatened under the California Endangered Species Act (CESA). Therefore, any activities that could potentially cause harm to the species must be reviewed by the California Department of Fish and Game (CDFG), and then such activities must be authorized through a formal permit. Such permits are authorized under section 2081 of the California Endangered Species Act. If CDFG feels that no additional terms or conditions are necessary in addition to those listed in the Federal permit, not uncommonly CDFG will not issue a separate permit but instead will issue a concurrence letter.

3.6.3. California Department of Fish and Game Authorizations

In situations such as relocation where animals will be handled, CDFG commonly issues a Memorandum of Understanding authorizing project proponents to handle a state-listed species, and may impose terms and conditions which may differ to some degree from those listed in the Federal permit. Also, to capture and/or handle any wildlife within California, a Scientific Collecting Permit from the CDFG is required.

3.6.4. National Environmental Policy Act

A proposed kit fox relocation would be subject to public review and comment under the National Environmental Policy Act (NEPA). Such review is required because a Federally listed species is involved and because a Federal agency (U.S. Fish and Wildlife Service) is involved.

3.6.5. California Environmental Quality Act

Similarly, a proposed kit fox relocation also would be subject to public review and comment under the California Environmental Quality Act. Such review is required because a state listed species is involved and because a state agency (California Department of Fish and Game) is involved.

3.6.6. Landowner permissions

Finally, landowner permission obviously would be required prior to the introduction of kit foxes onto a reintroduction site. Obtaining such permission will be easiest if the reintroduction site is owned by a Federal or state natural resources agency. Conservation of biodiversity and rare native species should fall within the mandate of these agencies. Use of lands owned by other public agencies also would require permissions, and also possibly some sort of formal agreements to indemnify these agencies in the event of accidental deaths of kit foxes.

Private lands might present the greatest challenge with regards to permissions, even if the landowner (be it an individual or organization) is willing to allow a kit fox reintroduction. To protect both the landowner and the newly established kit fox population, a formal agreement should be established. Such an agreement could take the form of a conservation agreement, conservation easement, Safe Harbor Agreement, or other type of agreement. These formal agreements would help to protect the landowner in the event of accidental deaths of a kit foxes from landowner activities, and also would help ensure that the land remains suitable and available to kit foxes for an extended if not indefinite time.

3.7. POTENTIAL FUNDING SOURCES

Any relocation of San Joaquin kit foxes likely will be expensive. A very rough estimate of costs for a 5-year relocation effort initiated in 2008 is approximately $1.5 million. Thus, conducting such an effort likely will necessitate multiple funding sources operating collaboratively in a coordinated effort. Below is an annotated list of potential funding sources. This is by no means an exhaustive list.

3.7.1. Central Valley Project Conservation Program

The CVPCP provided the funding for this literature review and also has provided funding for a field investigation of suitable source populations and individuals for any relocation effort. The CVPCP and closely related CVP Habitat Restoration Program have been significant active participants in the restoration and conservation of San Joaquin Valley ecosystems.

3.7.2. Bureau of Reclamation South Central California Area Office

The BOR SCCAO has been a significant source of funding for listed species conservation efforts in the San Joaquin Valley. The BOR SCCAO has been a primary source of funding for CSUS Endangered Species Recovery Program efforts.

3.7.3. U.S. Fish and Wildlife Service

The FWS might be able to provide funding, either through Recovery Program funds or other sources.

3.7.4. California Department of Fish and Game

The CDFG also might be able to provide funding. This funding could come from various mitigation monies collected by CDFG, or also possibly from Section 6 grants. Additionally, CDFG may be able to provide in-kind support in the form of labor (e.g., refugia construction, monitoring), materials, logistic support, or veterinary services.

Support from CDFG would be particularly appropriate if state lands (e.g., Allensworth ER) were used for reintroduction sites.

3.7.5. U.S. Bureau of Land Management

The BLM occasionally has funding for listed species research and restoration projects. Similar to the CDFG, the BLM might be able to provide in-kind support in the form of labor or materials. Some of the retired agricultural lands are being place under BLM management, and if such lands were used for relocations, BLM support would be very appropriate.

3.7.6. Conservation organizations

Non-profit, non-governmental conservation organizations might be interested in supporting a kit fox relocation effort. This could include both local organizations and national groups. Local groups might include the Tulare Basin Wildlife Partners, San Joaquin Chapter of the Wildlife Society, or local Audubon Society Chapters. Groups like these tend not to have significant financial resources, but might be able to provide volunteers or other services. National conservation organizations could include groups like The Nature Conservancy, Defenders of Wildlife, Environmental Defense, or National Wildlife Federation. All of these groups provide funding for wildlife restoration projects.

3.7.7. Foundations

A number of private foundations support environmental improvement projects, and it is possible that one or more might be interested in supporting a kit fox restoration effort. The Packard Foundation in particular has supported environmental enhancement projects in California, and indeed, lists the Central Valley as a region of interest.

3.7.8. National Fish and Wildlife Foundation

The NFWF has historically supported ecosystem restoration projects. Funding from NFWF is in the form of matching grants, and non-Federal resources must be used for the match. Matching resources can include both funds and in-kind resources.

3.8. TECHNICAL GROUP

Relocating a rare species with the intention of establishing a new population obviously is a complex task. Based on the information presented in this report, it should be abundantly clear that considerable planning will be required and that a multitude of issues must addressed before any relocation effort can be initiated. Such planning and issue resolution is absolutely required given the (1) high risks involved with animal translocations, (2) considerable expense involved, and (3) necessity for minimizing losses given that a rare species is involved.

Thus, the formation of a technical group to assist with planning and coordination is highly recommended. Such a group should consist of species experts, regulatory agencies, one or more veterinarians, release site landowners, and possibly primary funding source representatives. This group should be selected and convened 1-2 years prior to planned relocations to provide adequate time to identify source populations and release sites, plan strategies, develop protocols, ensure that permits and permissions are obtained, and ensure that sufficient resources (e.g., financial, material, human) are secured.

4. RECOMMENDATIONS FOR NEXT STEPS

4.1. *INVESTIGATE SUITABLE SOURCE POPULATIONS AND INDIVIDUALS*

We recommend that an investigation be conducted to determine whether urban or natural lands kit foxes would be the most suitable candidates for use in a relocation effort, and whether particular individuals may be behaviorally better suited for relocation. A proposal has been developed and such an investigation has been funded by the Central Valley Project Conservation Program. This investigation is being conducted by ESRP and is in its second year. Results to date are quite promising and informative, and funding has been requested for an additional year of field work. Quarterly progress reports have been prepared and submitted to CVPCP, and a final report will be submitted either by October 2007 or October 2009 if the project is extended.

4.2. *IDENTIFY AND EVALUATE POTENTIAL REINTRODUCTION SITES*

As discussed in this report, there are at least 2 sites that potentially could be suitable for the reintroduction of kit foxes. Additional sites may warrant consideration as well. All such sites should be identified and a 2-phase evaluation process conducted.

4.2.1. Phase I

This phase should include assessing the total acreage available at each site, evaluating the general habitat type and condition, determining land ownerships, determining whether landowners would consider the reintroduction of kit foxes, and determining the factors responsible for the absence of kit foxes at a site and whether or not such factors have been or could be mitigated. This first step could be completed largely with map work and with 1 or 2 “windshield” tours of each site.

4.2.2. Phase II

Assuming that all of the checks in the Phase I assessment are satisfactory, than more intensive site evaluations should be conducted. These evaluations should include assessments of prey availability, competitor abundance, and den availability. Additionally, any management strategies that might increase habitat suitability for kit foxes (e.g., grazing) could also be identified during this phase.

A proposal has been submitted to the CVPCP for support to conduct Phase I and II evaluations at 2 potential release sites: the Allensworth area and the retired agricultural lands area. If the project is funded, these evaluations will be completed in 2008-2009.

4.3. ASSESS AGENCY SUPPORT FOR A RELOCATION EFFORT

If one or more sites are indeed evaluated and if at least one is found suitable for a reintroduction effort, then the U.S. Fish and Wildlife Service and the California Department of Fish and Game should be consulted to determine whether these agencies would support a reintroduction effort at this time. Such an effort could be a full-scale effort with the goal of establishing a new kit fox population, or it could be a trial effort with the goal of testing relocation techniques.

4.4. SECURE FUNDING AND COOPERATORS FOR A RELOCATION EFFORT

If one or more suitable reintroduction sites are identified and the regulatory agencies support a relocation effort, then the next step will be to secure funding, permissions, and cooperator support for a relocation effort. As part of this step, a technical group should be formed and all aspects of the relocation effort should be carefully planned.

4.5. CONDUCT A RELOCATION EFFORT

Once all appropriate steps have been completed, as described in this document, then a kit fox relocation effort could be attempted. The establishment of any additional populations will contribute to the range-wide stability, security, and recovery of San Joaquin kit foxes.

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