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ISLAND FOX RECOVERY PROGRAM
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Executive Summary

From 1995 to 2000, island fox (*Urocyon littoralis*) populations on San Miguel, Santa Rosa and Santa Cruz Islands declined by as much as 95% due to predation by golden eagles (*Aquila chrysaetos*). Faced with the likely extinction of 3 island fox subspecies, the National Park Service began implementing recovery actions for island foxes on the northern Channel Islands in 1999. Such actions included removal of golden eagles and captive breeding of island foxes. In this report we describe progress in island fox recovery in 2005.

During 2005, the National Park Service continued its program of captive breeding and release of island foxes on San Miguel and Santa Rosa Islands. Reproduction in captivity in spring 2005 was equivocal and a considerable number of litters were lost, due to one or more of the following factors: poor late spring weather, mate aggression, and mastitis. Island foxes released to the wild the previous year (in fall 2004) on San Miguel all survived, and exhibited surprisingly good reproduction in spring 2005. Island foxes released in fall 2004 on Santa Rosa Island incurred some predation by golden eagles, and, as on San Miguel, exhibited good reproduction in spring 2005. On the strength of this wild recruitment, U. S. Fish and Wildlife Service recommended large releases to the wild on both islands in fall 2005, and those were conducted. By the end of 2005 wild populations of about 40 foxes had been established on each island, and the total number for each subspecies had increased to approximately 70 foxes (each had declined to 14 foxes by 2000).

On Santa Cruz Island, island fox captive breeding and wild island fox monitoring are conducted by the Institute for Wildlife Studies, funded by The Nature Conservancy. Data from that program are reported separately, and are summarized here. Captive island foxes produced 20 pups in captivity on Santa Cruz in 2005, bringing the captive population to 62 foxes. The USFWS recommended against releasing island foxes to the wild on that island, and so none were released in 2005. Good reproduction and survival in the wild increased the wild population to approximately 150 individuals by the end of 2005. The Nature Conservancy intends to release as many as 50-60 Santa Cruz Island foxes to the wild in 2006.

One adult and one juvenile golden eagle were captured and relocated from Santa Rosa Island during 2005, leaving as few as 4 golden eagles on Santa Cruz and Santa Rosa Islands.

San Miguel

With the birth of 10 pups in spring 2005, and the mortalities of 2 adults, the captive island fox population on San Miguel Island grew to 48 foxes, of which 1 escaped from captivity in June 2005, and 21 were released to the wild in fall 2005. One released fox died in March 2006, of unknown causes.

On San Miguel, 6 of 18 pairs (33%) produced litters in 2005. Of the 10 pups born in captivity in 2005, 6 were female. One new founder, female B0B25, bred in 2005, increasing the number of founders for the San Miguel population to 8. Seven captive-born and 5 wild-born females failed to produce litters in 2005. Two females lost litters and died due to complications from mastitis. Five other females possibly lost litters, as well.

Foxes were first released back into the wild on San Miguel in fall 2004. Foxes had been absent from the island since 1999, when the remaining animals were brought into captivity. The 10 foxes released in 2004 all survived through 2005. The 4 females released all established breeding territories and produced litters in spring 2005, and a total of 10 wild-born pups (5 males, 5 females) were recruited into the population. One wild-born juvenile died from predation in January 2006.

Twenty-one foxes (12 males, 9 females) were released to the wild between 14 October and 06 December, 2005, at a total of 7 release sites on San Miguel Island. As of 15 April 2006, 20 of 21 released foxes were alive, with functioning radiocollars. Currently there are a total of 40 foxes (23 males, 17 females) in the wild on San Miguel.

As per studbook recommendations from the American Zoo and Aquarium Association, 3 existing San Miguel captive pairs were broken up, and 5 new pairs were created after releases to the wild. One of the new pairs was later separated, due to mate aggression.

Santa Rosa

With the birth of 8 pups in spring 2005, the captive island fox population on Santa Rosa Island grew to 51 foxes, of which 17 were released to the wild in fall 2005. As of 15 May 2006, 2 of those 17 had died from predation, and another 2 had died of unknown causes (not predation). Additionally, foxes released in 2004 died from predation, as did 2 juveniles born in the wild in spring 2005.

On Santa Rosa, 4 of 19 captive pairs (21%) produced litters in 2005. Of the 8 pups born in captivity in 2005, 6 were male. No new founders bred in 2005, and the number of founders remained at 12. Ten captive-born and 5 wild-born females failed to produce litters in 2005. Six females lost litters and one other female possibly lost a litter.

In fall 2003 foxes were first released back into the wild on Santa Rosa, where they had been missing since 2000, when the remaining animals were brought into captivity. A second release, of 13 foxes, occurred in fall 2004. Five of the 13 foxes died from golden eagle predation between November 2004 and April 2005. Although the number of deaths due to predation exceeded the threshold at which foxes would be returned to captivity, U. S. Fish and Wildlife Service advised the park not to recapture foxes, due to possible impacts on breeding females. A total of 3 females bred in the wild in spring 2005, producing 9 pups (3 males, 6 females) which were recruited into the wild population.

Seventeen foxes (9 males, 8 females) were released to the wild between 01 October and 26 November, 2005, at a total of 5 release sites on Santa Rosa Island. Currently there are a total of 32 foxes (14 males, 18 females) in the wild on Santa Rosa.

As per studbook recommendations from the American Zoo and Aquarium Association, 9 existing Santa Rosa captive pairs were broken up, and 11 new pairs were created after releases to the wild.

All captive San Miguel and Santa Rosa island foxes were given annual veterinary examinations, at which time blood samples were taken from all animals for hematology and complete blood chemistry. All captive foxes were vaccinated against canine distemper virus and, for the first time, against rabies. Captive animals requiring treatment for injuries or other ailments were given veterinary care as required.

On each island 10 to 20 additional island foxes will be released in fall 2006, provided that eagle predation does not force implementation of contingency measures, and provided that captive pup production in spring 2006 is adequate. Foxes will be released to the wild under an annual release plan developed in summer 2006.

It is estimated that captive breeding and annual releases may continue for as long as 10 years, until San Miguel and Santa Rosa Island foxes have reached target population sizes that insure the likelihood of persistence over time.

Other Management Actions Required

Removal of feral pigs (*Sus scrofa*) from Santa Cruz Island began in early 2005 as a joint project funded by The Nature Conservancy and NPS and implemented by TNC via contract. Complete removal is estimated to take 2-4 years, but by early 2006 over 5,000 pigs had been removed and by mid-2006 the bulk of the island's pigs will be gone.

The NPS is also cooperating with other agencies in a feasibility study to determine if bald eagles (*Haliaeetus leucocephalus*) can be restored to the northern Channel Islands. Monies from the settlement of the Montrose contaminant case are funding the 5-year program, in which up to 12 young bald eagles will be released on Santa Cruz Island annually. By the end of 2005 approximately 30 bald eagles remained on Santa Cruz and Santa Rosa Islands from summer releases in 2002-2005. Additionally, a pair of bald eagles from Santa Catalina Island incubated eggs in a nest on Santa Cruz in 2006. This was the first bald eagle nest on the northern Channel Islands since 1949. The first nesting attempts by eagles released on Santa Cruz Island may occur in spring 2007, when the eagles from the first release in 2002 are 5 years old.

Introduction

The island fox, a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. The fox exists as 6 different subspecies on each of the 6 largest islands, a distinction upheld by morphological and genetic work (Wayne et al. 1991, Collins 1993). In 2004, the U.S. Fish and Wildlife Service listed as endangered 4 island fox subspecies, including the 3 subspecies in the Park (San Miguel Island fox [*U. l. littoralis*], Santa Rosa Island fox [*U. l. santarosae*], and Santa Cruz Island fox [*U. l. santacruzae*]) as well as the subspecies on Santa Catalina Island (*U. l. catalinae*) (U.S. Fish and Wildlife Service 2004). The 3 park subspecies had declined due to high levels of predation by golden eagles (*Aquila chrysaetos*).

Annual population monitoring detected the fox declines on San Miguel and Santa Cruz Islands. The island fox population on San Miguel declined from an estimated 450 adults in 1994 to 15 in 1999 (Coonan et al. 2005c). The Santa Cruz population declined from as many as 2,000 adults in 1994 to 50-60 in 2000 (D. Garcelon, Institute for Wildlife Studies, unpubl. data). Foxes on Santa Rosa may have numbered more than 1,500 in 1994 (Roemer et al. 1994) but declined to 14 animals by 2000 (Coonan and Rutz 2001). Prior to implementation of island fox recovery efforts, Roemer (1999) estimated time to extinction at 5 years for island foxes on San Miguel and 12 years for island foxes on Santa Cruz.

Predation by golden eagles (*Aquila chrysaetos*) is the primary mortality factor for island foxes on the northern Channel Islands, and is responsible for the massive decline of the 3 northern subspecies from 1994 to 2000 (Roemer et al. 2001a). Evidence from several studies supports this. Golden eagle predation was identified as cause of death for 19 of 21 island fox carcasses found on Santa Cruz Island from 1993 to 1995 (Roemer et al. 2001a). On San Miguel Island in 1998-1999, 4 of 8 radiocollared island foxes were killed by golden eagles in a 4-month period (Coonan et al. 2005c). Recent work on Santa Cruz Island confirms the continuing influence of eagle predation. From January 2001 through March 2006, 34 of 47 mortalities of radiocollared foxes on Santa Cruz Island were due to golden eagle predation (D. Garcelon, Institute for Wildlife Studies, unpubl. data).

Until the 1990s, golden eagles never bred on the Channel Islands, and their recent appearance is due to a prey base, feral pigs (*Sus scrofa*) and mule deer (*Odocoileus hemionus*), that was not present prehistorically (Latta et al. 2005, Collins and Latta 2006). The absence of bald eagles (*Haliaeetus leucocephalus*),

which bred historically on the islands and whose presence may have kept golden eagles away, may also have facilitated golden eagle colonization of the islands (Roemer et al 2001a). Island foxes evolved in the absence of significant diurnal aerial predators such as the golden eagles, and therefore may have been more vulnerable to predation than other small carnivores. Moreover, on much of the northern Channel Islands, historic sheep grazing changed the predominant vegetation from shrub to non-native grasslands, which offer much less cover from aerial predators.

Upon receiving recommendations from a convened panel of experts, the Park began taking emergency recovery actions in 1999. In summer 1999, the Park constructed pens on San Miguel and began capture of wild island foxes. By January 2000, 14 island foxes had been captured and placed in the pens, leaving only 1 in the wild. Four of the captured foxes were males, and so were paired with 4 females for breeding. In 2004, after 5 years of breeding the San Miguel captive population had increased to 50 animals, exceeding the target captive population size of 40 animals and allowing initial releases back to the wild in fall 2004.

A captive breeding program was initiated for Santa Rosa Island in 2000. The initial captive population on Santa Rosa was 14 animals, which proved to be the island's remaining fox population. Some females were pregnant when captured, and 3 litters were born in captivity in 2000. With an increase to 56 foxes in 2003, the captive population on Santa Rosa exceeded the target captive population size of 40 foxes, and initial releases began in winter 2003/2004.

The status of eagles and foxes on Santa Cruz Island was assessed at the 2001 meeting of the Island Fox Conservation Working Group, with consensus being that captive breeding was warranted for that island fox population. In February 2002, a 10-pen captive breeding facility was built on Santa Cruz Island by the National Park Service and The Nature Conservancy. This facility was stocked with 12 adult island foxes caught in pairs or as individuals from separate areas of the island. A second facility was added in 2004. No releases occurred in either 2004 or 2005, and the captive population grew to 62 animals in 2005.

The Park established a cooperative agreement with the Santa Cruz Predatory Bird Research Group (SCPBRG) in 1999 for the purpose of relocating golden eagles from the northern Channel Islands. Personnel from the SCPBRG began eagle survey and removal on Santa Cruz Island, the island with the most recent sightings, in late summer 1999. Golden eagles were discovered to breed on both Santa Cruz and Santa Rosa Islands. By the end of 2005, 41 golden eagles had been removed from Santa Cruz Island, the majority by bownet

trapping. Captured birds were released in northeastern California, and satellite telemetry on the first released birds indicates that none attempted to return to the islands (Latta et al. 2005).

In 2003, the Park completed a recovery strategy for island foxes on the northern Channel Islands (Coonan 2003). The recovery strategy is in the format of a U.S. Fish and Wildlife Service recovery plan, identifying threats to the species, delineating goals, objectives and recovery criteria, and presenting a schedule and cost estimates for recovery actions. Appropriate recovery goals for each of the 3 island fox subspecies in the northern Channel Islands were determined via demographic modeling (Roemer et al. 2001b). Population viability analysis was used to identify target population levels which would minimize the chance of extinction. Modeling was then used to set an augmentation (captive breeding and release) schedule that would achieve those targeted goals in a reasonable timeframe.

The island fox recovery strategy calls for a continuation of the emergency actions of island fox captive breeding and golden eagle removal, as well as the separately funded actions of feral pig removal from Santa Cruz Island and reintroduction of bald eagles to the northern Channel Islands. The document predicted that full recovery of island foxes on San Miguel and Santa Rosa Islands may take over a decade, although recovery on Santa Cruz Island might be achieved sooner.

The Park's island fox recovery strategy will be superseded by an official island fox recovery plan currently being developed under the direction and authority of the U.S. Fish and Wildlife Service.

Integrated Island Fox Recovery Team

From 1999-2003, the NPS convened a group of experts annually to help evaluate the status of island foxes on Park lands, and to make findings regarding appropriate recovery actions. The Island Fox Conservation Working Group, as it was called, comprised a loose affiliation of public agency representatives, landowners, conservancies, zoological institutions, non-profits and academics concerned about conservation efforts for the island fox.

The working group served as a forum for information exchange and evaluation of recovery efforts, dividing into subject matter groups to tackle most issues. The group annually reported the status of island foxes on all islands and listed findings in

regard to threats to the species and appropriate mitigation actions (see Appendix A in Coonan et al. 2004).

After listing 4 island fox subspecies as endangered in 2004, the U.S. Fish and Wildlife Service established an island fox recovery team that retained the characteristics of the Island Fox Conservation Working Group. Although many recovery teams comprise a small number of individual experts, the Service established an integrated island fox recovery team comprising all 70+ individuals from the former working group. The individuals are members of specific technical expertise groups, from which individuals are chosen to work on task forces in response to requests from land management agencies (NPS, TNC, Santa Catalina Conservancy) regarding management and recovery of island foxes. The task requests are allocated to task groups by the island fox recovery coordination group, which also receives the resulting analyses from the task groups and passes on recommendations to the land management agencies, via the Service.

The integrated island fox recovery group met in June 2004 to establish technical expertise groups and task forces, and begin addressing the task requests formulated by the land management agencies. The team met again in June 2005 to exchange information on fox conservation and research, review completed work on task requests and recommendations to land managers, and to continue work on task requests. Information on the integrated island fox recovery team is available from the Ventura Field Office of the U.S Fish and Wildlife Service.

Island fox released to the wild, San Miguel Island

Captive Breeding Program Development

The Need for Captive Breeding as a Recovery Action

The Park's island fox recovery strategy (Coonan 2003) identifies captive breeding as a critical recovery element necessary to recover island fox populations to viable levels on the northern Channel Islands. Current island fox populations on San Miguel, Santa Rosa, and Santa Cruz Islands number 65, 68, and >210 foxes, respectively. The probability of extinction is still high for these low populations (Roemer et al. 2001b) and the populations require augmentation to reach viable levels. Demographic modeling suggests that an appropriate augmentation schedule can return island foxes to viable population levels within a reasonable timeframe (a decade). The former Island Fox Conservation Working Group recommended captive breeding as a recovery action. Once golden eagles are removed from the northern Channel Islands, captive breeding and release to the wild will be the most important recovery action implemented for island foxes, and will require commitments of resources and personnel far exceeding any other recovery action.

Goals and Objectives for Captive Breeding

The following goals and objectives for the island fox captive breeding program at Channel Islands National Park were developed upon consultation with the captive breeding sub-group of the Island Fox Conservation Working Group (see Coonan and Rutz 2001).

Overall Goal

To develop a captive breeding program for island foxes on San Miguel Island (*U. l. littoralis*), Santa Rosa Island (*U. l. santarosae*) and Santa Cruz Island (*U. l. santacruzae*) in order to increase their wild populations to viable levels.

Overall Objective

To design and implement captive breeding programs for the primary purpose of generating animals suitable for reintroduction into appropriate habitat, once the threats to the populations in those habitats have been minimized or eliminated.

Specific Objectives

1. Define scope and duration of program; set facility size and configuration.
2. Construct and populate breeding facilities for the San Miguel, Santa Rosa and Santa Cruz Island fox populations.
3. Pair animals for breeding; monitor breeding behavior and results.
4. Develop appropriate release strategies.
5. Release foxes annually back into the wild; monitor wild foxes.

Program Guidance

Guidance for the captive breeding program was provided generally by the captive breeding and veterinary sub-groups of the Island Fox Conservation Working Group, and their findings and recommendations were incorporated into the Park's captive breeding program (Coonan and Rutz 2001, 2002, 2003, Coonan et al. 2004, 2005c). For guidance in design of captive enclosures and development of husbandry protocols, we consulted the American Zoological Associations' management recommendations for small canids in captivity, as well as the American Society of Mammalogists' guidelines for the capture, handling and care of mammals (American Society of Mammalogists 1998). Moreover, the Santa Barbara Zoo has organized two island fox husbandry workshops and has produced island fox husbandry guidelines incorporating recent experience in island fox husbandry. The results from those workshops have been incorporated into the park's captive breeding program.

Standard Operating Procedures

The following general standard operating procedures have been developed for the captive breeding program. More specific standard operating procedures (Appendix A) are updated annually to reflect new knowledge gained in island fox husbandry :

Facility Design and Construction

- In order to minimize the chance of disease, parasites or other catastrophe causing extirpation of captive populations, San Miguel and Santa Rosa Islands each have two separate breeding facilities.
- Staff level must be adequate for caretaking 40-50 animals at two sites.

- Sufficient distance is maintained between pens. Within the pens hiding places are provided; thus animals have visual contact with others when they choose.
- Annual pen construction is completed by October to allow pairs sufficient time to bond prior to breeding.
- There should be a minimum of two isolation areas at each facility.
- The threat of wildfire at captive breeding facilities is addressed by the Park's fire management program, and Vari-Kennels are available for immediate evacuation of foxes.
- Perimeter or electric fences are required at most facilities to prevent contact between captive and wild foxes. Aggressive encounters through the pen walls have been a source of injuries to both captive and wild foxes.

Veterinary Care

- If foxes are brought to the mainland for veterinary care, they cannot be returned to the islands, because of possible disease/parasite transmission.
- Captive foxes are given annual veterinary examinations, using a standardized veterinary protocol.
- Each captive breeding population has access to a veterinary/quarantine facility where animals may be treated.
- Protocols are implemented to minimize the risk of people or equipment transferring pathogens among islands, and to minimize parasite loads in the captive populations.
- Captive foxes are vaccinated annually against canine distemper virus, using a Canary pox vectored recombinant vaccine (Purevax Ferret Distemper vaccine, Merial Ltd., Athens, GA), and against rabies (IMRAB 3 rabies vaccine, killed virus, Merial Ltd., Athens, GA).

Caretaking and Handling

- Human contact with captive foxes is minimized to avoid acclimating them to humans, and to ensure they are as wild as possible upon release.
- Handling and disturbance of captive island foxes is avoided during the full extent of the breeding season (January through June).

Breeding Strategy

- In order to insure the genetic integrity of the captive fox populations, selection of animals for pairing and for release to the wild is accomplished via an analysis and population management plan produced annually for each subspecies by the American Zoo and Aquarium Association's Population Management Center. Birth, death and breeding records are maintained in a studbook.
- Mated pairs are kept together as long as they reproduce successfully; non-reproductive pairs are kept together for at least two breeding seasons.
- Excess females may be housed together if compatible to allow for social interaction or to possibly test reproductive potential of one male with two females. However, no more than two females should be housed together in one pen.

Diet

The standard diet for captive island foxes (see Coonan et al. 2005a) was modified in 2005 to better manage captive fox weights. Concerns about excessive weight gain in captive foxes arose during the annual veterinary exams in 2004. After considerable consultation, the consensus among project veterinarians Drs. Karl Hill, Winston Vickers, and Mark Willett was to change to a lower caloric base kibble. At their suggestion the base kibble was changed from Innova Adult dog kibble (Natura Pet Products; Santa Clara, CA) to Science Diet Adult (SDA) dog kibble (Hill's Pet Nutrition; Topeka, KS).

At the beginning of 2005, kibble amounts served were the same as the previous year: 1/2 cup per fox, with supplements (a mixture of fruits, vegetables, nuts, mice, and quail). In mid-March, overall kibble amounts were increased 50% (to 3/4 cup per fox) due to concerns about underweight foxes on Santa Cruz Island, and those kibble amounts were served through fall 2005.

Also beginning in March, captive fox pair diets were switched over to the reproductive diet, in anticipation of the energetic needs of females during whelping and lactation. On March 15th, Science Diet Pup (SDP) kibble was introduced into their diets (3 SDA:1 SDP). Over the next several weeks, SDP kibble was slowly increased and SDA kibble decreased until the ratio reached 1 SDA:1 SDP. On April 18th, increases in SDP kibble began, dependent upon direct observations of pups, behavior indicative of reproduction, and whether the food offered was being completely consumed consistently. In early/mid May, due to concerns over pup and female mortalities, Dr. Vickers conducted

examinations of foxes on all three islands. Blood tests conducted on lactating females revealed calcium levels to be low. Therefore in addition to their reproductive season diet, pens with pups were given additional hard-boiled eggs throughout the week and either mice or quail (items high in calcium) daily. Also, diets were corrected for pup numbers, as determined by pup counts during examination. By June, diets were maxed out at 3/4 cup kibble per fox (adult or pup).

As in the previous year, a number of overweight foxes were discovered during the summer 2005 annual veterinary exams, and two corrective actions were taken. First, most foxes were put on a weight reduction diet (base kibble was reduced from 3/4 cup to 1/3 - 1/2 cup per fox). Food toys, live mice, and scattering were used to equalize food consumption between members of mated pairs in pens with weight problems. A maximum release weight of 2.8 - 2.9 kg was set for foxes slated for release.

Second, development was begun on a new captive fox diet that would hopefully provide a longer term solution to the weight problems. The new diet was based upon the Santa Barbara Zoo's island fox diet (designed by Dr. Hill). The new diet introduces cat kibble into the kibble mix being fed to foxes. Under the new diet, each adult fox is fed a 2:1 mixture of adult dog and adult cat kibble daily. As in the previous diet, the kibble is supplemented with fruits, vegetables and hard-boiled eggs. Additional supplements in the new diet include insects (such as mealworms) and frozen mice. To increase calories and nutrition during breeding, each fox pair is switched over to a 2:1 mixture of puppy and kitten kibble, and the amounts of supplements are increased. Some components of the diet were added late in 2005 (for example, mealworms in October). The new diet was fully implemented in February 2006.

Overall Breeding Success

In 2005, the San Miguel captive population increased from 38 to 48 individuals, with 10 pups born to 6 litters. On Santa Rosa the captive population increased from 43 to 51 individuals with 8 pups born to 4 litters. The captive population on Santa Cruz increased to 62 individuals with the addition of 20 pups born to 10 litters.

Twenty of 56 paired females produced litters in 2005 (36%), compared to 16 of 44 in 2004 (36%), 14 of 38 in 2003 (37%), 9 of 21 in 2002 (43%) and 7 of 13 in 2001 (54%). The proportion of paired foxes that had litters was greater on Santa Cruz (10 of 20) than on San Miguel (6 of 18) or Santa Rosa (4 of 19), due to

the effects of mastitis in the latter two captive populations (W. Vickers, Institute for Wildlife Studies, unpubl. data; see discussions on pgs. 22 and 35). In 2005, two San Miguel captive adult females died from septicemia/mastitis, and their litters were lost. An additional 8 females from San Miguel and Santa Rosa lost litters due to mastitis, and 5 additional females may have lost litters.

Mate-caused aggression was less during the 2005 breeding season compared to previous years, in which some pairs formed in the fall have had to be separated, due to aggression-caused injuries. In 2005 only 1 pair, on San Miguel Island, was split due to aggression prior to the breeding season.

One new founder was added to the San Miguel captive population in 2005, increasing the number of San Miguel founders to 8. One potential female founder died of mastitis, and 2 others are likely too old (>12 years) to breed. There are 2 potential founder males left in the captive population, and they are paired with females for the 2006 breeding season.

No new founders were added on Santa Rosa, where 12 of 14 potential founders have bred since program inception. The 2 potential founders left are females paired with males for the 2006 breeding season.

Overall, reproductive output in captivity is similar to that observed in the wild. The average number of pups weaned in captive litters (2.3, n = 69 litters) is slightly higher than the average number of pups weaned in the wild on San Miguel from 1993 to 1998 (2.0, n = 34) (Coonan et al. 2004). There was little difference among islands in the average number of pups weaned in captivity (Table 1).

The proportion of females that has produced litters in captivity is also similar to that observed in the wild. In captivity, 69 of 179 annual pairings (38.5%) have produced litters (Table 2), compared to 42.8% in the wild (54/126 pairings; Coonan et al. 2004). The proportion of females breeding is higher on Santa Cruz as on San Miguel or Santa Rosa, perhaps because a greater proportion of pairs on Santa Cruz have involved wild-born females, and females on Santa Cruz have lost less litters than those on San Miguel and Santa Rosa.

As in the wild, female age affected the probability of producing a litter. Only 17% (8 of 47 pairings) of paired juvenile females produced litters in captivity, compared to 45.4% (54 of 119 pairs) of older females. This is similar to results from the wild. On San Miguel in 1993-1999, 19% of Age Class I females

produced litters, compared to 60% of older females (Coonan et al. 2005c).

Mate history also affected likelihood of breeding. Most captive fox pairs were not successful in their first year of mating. Only 23.8% of 80 first-year matings were successful, whereas 50.0% of 86 second and third-year matings were successful.

Table 1. Average number of pups weaned per litter, 1999-2005.

Island	Avg. No. of Pups Weaned	n
San Miguel	2.2	21
Santa Rosa	2.3	26
Santa Cruz	2.3	22

Table 2. Proportion of annual pairings that produced litters, 1999-2005.

Island	Litter	Total	% Success
San Miguel	21	64	32.8
Santa Rosa	26	76	34.7
Santa Cruz	22	40	55.0
Total	69	180	38.3

In summary, reproductive success for captive foxes has been similar to that previously recorded for wild foxes. Juvenile females rarely bred, and the average number of pups weaned was similar for captive and wild foxes. First-year matings were less successful than matings involving second and third-year pairings. The primary factor which affected reproductive success in 2005 was an outbreak of mastitis in the San Miguel and Santa Rosa captive populations. Mastitis was responsible for loss of litters on both islands and for the deaths of two adult females on San Miguel Island.

Study of Factors Affecting Reproductive Success

In 2005, the land management agencies, upon the recommendation of the RCG, funded a study of factors affecting reproductive success in captive island foxes on the northern Channel Islands. The study was conducted by Dr. Kathy Carlstead of the Honolulu Zoo. Dr. Carlstead evaluated the influence of fox behavior, pen characteristics and fox background (wild-born versus captive-born) on performance variables such as litter production, mate aggression, occurrence of mastitis, and individual weight and body condition, for the 2005 breeding season. Preliminary results (Carlstead 2005) underscore the influence of mastitis on

reproduction. If lost litters were counted as “births”, there was no difference among captive breeding sites. Behavior profiles were constructed, comprising measurement of two traits: whether each fox was relatively more calm or tense, and the degree of compatibility or incompatibility of each pair. Pairs with mate aggression had higher scores for incompatibility (measured by signs of food competition and average distance apart). Differences also occurred due to fox background. Captive-born females were more tense than wild-born females, captive-born males were more likely to exhibit mate aggression, and wild-born males sired more litters than captive-born males. Pairs with mixed backgrounds (wild-born paired with captive-born) were more likely to lose a litter. Pens where technicians spent less time cleaning were more likely to lose litters, suggesting that increased monitoring inside the pen might reduce litter loss. Mastitis was more common in pens with high exposure to winds, less perimeter covering, and low den height. Conversely, pens with more perimeter covering (>27%) were less likely to lose litters.

To the extent possible, findings and recommendations from the study were incorporated into pen improvements implemented in 2005 (see below).

A second captive fox reproductive study (Sovada 2005) began in 2005. Principal investigators Dr. Cheryl Asa of the St. Louis Zoo and Dr. Marsh Sovada of the U.S.G.S Biological Resource Division’s Northern Prairie Research Center received funding from USFWS for a field study investigating factors affecting captive fox reproductive success. The primary objective was to identify the stage in breeding at which failure occurred. Cameras were installed in captive pens on Santa Cruz and Santa Rosa Islands in early 2006, and digital video image collection began shortly thereafter. The imagery will be reviewed and fox pair behavior quantified, in order to identify behavioral characteristics of successful and unsuccessful pairs. Cameras were not installed on San Miguel Island, due to logistical difficulties, but fox pairs on that island were directly observed from observation blinds during the breeding season. Weekly fecal samples were collected from pens during the breeding season, and will be analyzed for fecal hormone levels to determine estrous and ovulation, as well as degree of stress (as indicated by fecal cortisol levels). As part of the study, ultrasound examinations were conducted on all paired female foxes on the three islands in March 2006. Comparison of pregnancy rates with actual pups produced will quantify litter loss.

As part of the study, zoo personnel conducted mate-choice trials on the three islands in December 2005 to investigate whether mate-choice would alleviate mate-aggression and result in higher

reproductive success. In the trials, each female was presented with two males, each in a vari-kennel, to record female reaction to each male. However, none of the females on any of the islands exhibited any reaction at all to the males, and new pairings for the 2006 breeding season were subsequently made using genetic criteria alone (Lynch 2005a, 2005b).

Changes in Captive Fox Husbandry

Improvements were made to captive breeding pens on San Miguel and Santa Rosa Islands in 2005, in order to increase future reproductive success and decrease incidence of mate aggression and litter loss. Both the initial results of the reproductive factors study (Carlstead 2005) and findings by project veterinarian Winston Vickers (Vickers and Garcelon 2005) contained recommendations for changes in captive fox husbandry to address those issues.

Changes recommended by Carlstead (2005) included the following:

- Addition of more structures in pens
- Shadecloth covering >27% of pen perimeter
- Increased technician time inside the pens
- Insure no mold/moisture in denboxes
- Monitor captive-born males for aggression
- Monitor pairs for signs of incompatibility

Vickers and Garcelon (2005) concluded that the mate aggression observed in captivity was not the result of unsuitable mate selection, but was more likely due to the following: 1) insufficient space for separation of males and females; 2) inadequate number of denboxes for separation,; 3) inadequate escape locations for the female, and 4) encroachment of wild foxes which promote aggression between members of captive pairs. They recommended the following husbandry changes:

- Expansion of pens from current size of 500 ft^2 to 800-900 ft^2
- Replacement of current denboxes and addition of others, so there are at least 2 denboxes in each pen
- Measures to decrease moisture in denboxes
- Measures to decrease competition for food in pens
- Video monitoring to detect problems during whelping
- Increased direct observation of foxes during the breeding season
- Diet changes to increase calories, calcium and hydration during the breeding season

- Monitoring stress among captive foxes via fecal cortisol levels
- Ultrasound examinations to determine likely whelping times, so that observations can be intensified for individual pairs

During 2005, the above recommendations were implemented in the captive breeding program to the extent possible. Although logistical constraints prevented us from expanding pens to 800 or 900 ft^2, most pens housing captive pairs were expanded from 500 ft^2 to 600 ft^2 (which is the size of most pens on Santa Cruz Island). New denboxes (Fig. 1) were added, and old denboxes (most which dated from 1999 or 2000) were removed. The new denboxes have a heavy, tightly fitted roof to decrease moisture entry and allow for quick visual assessment of captive foxes. At least one large and one small denbox are now provided in each pen. Windshelters, shelves, hammocks and logs were added to each pen, as was additional shadecloth screening. A new diet is being implemented in 2006 (see p. 12). Ultrasound examinations were conducted in March 2006, and fecal cortisol monitoring is being conducted as part of the current reproductive study. Also in 2005, actions were taken to prevent wild foxes from entering the compounds. An overhang was installed at the Windmill Canyon captive breeding facility fence, and electric fence was added at both the Windmill Canyon and Caballo Muerto sites.

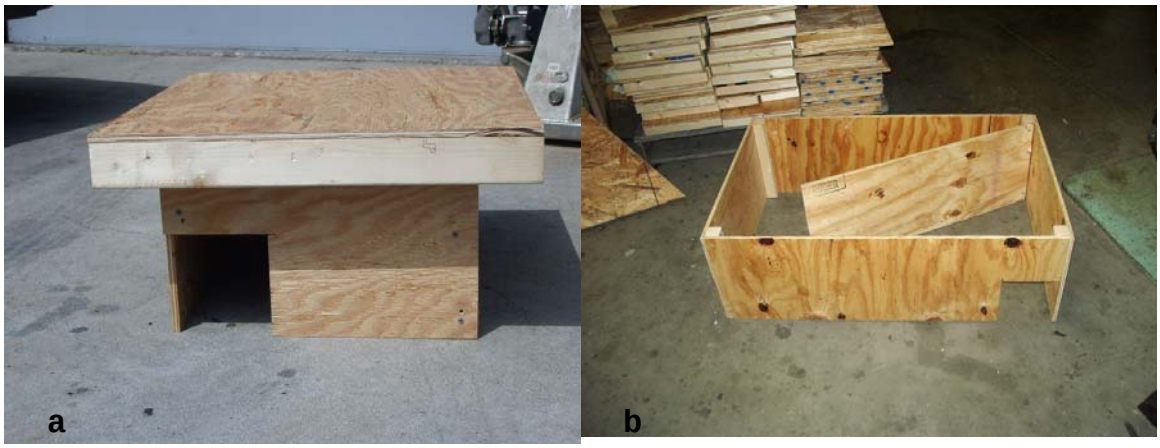

Figure 1. Design of new denboxes installed on San Miguel and Santa Rosa Islands in 2005: a) completed small denbox , b) cut out view of large denbox .

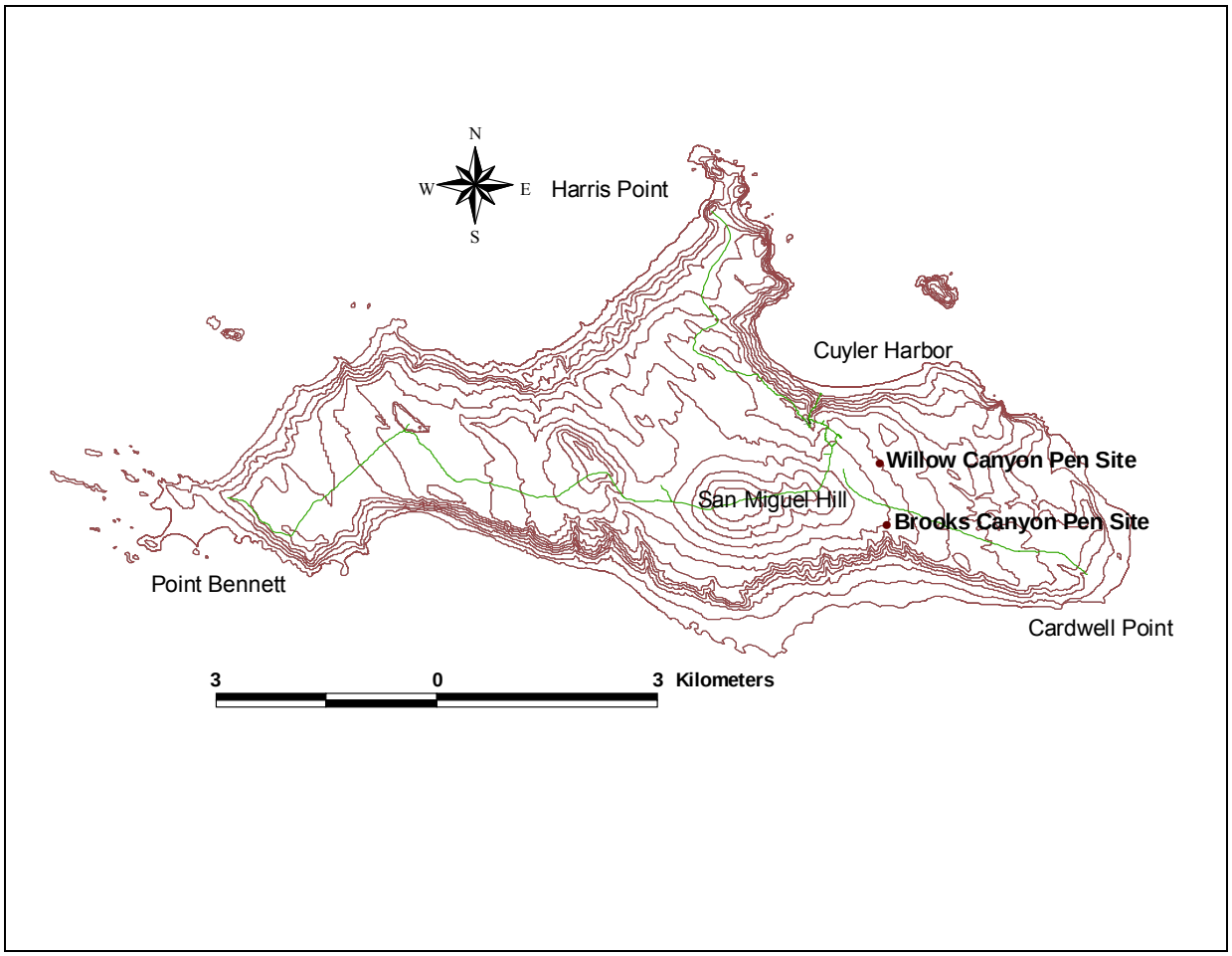

Figure 2. Location of island fox captive breeding facilities, San Miguel Island.

Recovery of San Miguel Island Foxes

With the birth of 10 pups in spring 2005, and the mortalities of 2 adults, the captive island fox population on San Miguel Island grew to 48 foxes, of which 1 escaped from captivity in June 2005, and 21 were released to the wild in fall 2005 (Table 3). One released fox died due to unknown causes in March 2006. Nine pups were weaned from 4 litters in the wild, and 1 of those wild-born juveniles died from eagle predation in January 2006. By April 2006 there were 26 adult foxes in captivity, and 39 in the wild, for a subspecies total of 65 foxes.

Captive Breeding

On San Miguel, 6 of 18 pairs (33%) produced litters in 2005. Of the 10 pups born in captivity in 2005, 6 were female. One new founder, female B0B25, bred in 2005, increasing the number of founders for the San Miguel population to 8. Seven captive-born and 5 wild-born females failed to produce litters in 2005. Two females lost litters and died due to complications from mastitis (Tables 4 and 5). Five other females possibly lost litters, as well (Table 5).

Table 3. Growth of captive island fox population, San Miguel Island.

	Adults			Pups					Total
Year	F	M	Total	F	M	Total	Died	Released	Captive
2000	10	4	14[1]	1	1	2	0		16
2001	11	5	16	0	5	5	1		20
2002	10	10	20	2	6	8	0		28
2003	13[2]	16	29	3	7	10	1		38
2004	15	23	38	8	4	12	0	10	40
2005	19	21	40	6	4	10	2	22	26

[1]Founding population
[2]Includes the last wild fox, female 33053, brought into captivity in September 2003; died in December 2003

Table 4. Island fox mortalities, San Miguel Island, 2005-2006.

PIT Tag	Release ID	Sex	Age	Date	Specimen Depository[1]	Area	Mortality Cause
60921	--	F	7	04/09/2005	UCD	In captivity	Septicemia subsequent to mastitis
11F6C	--	F	1	04/28/2005	UCD	In captivity	Septicemia subsequent to mastitis
C0934	F312	F	0.5	01/29/2005	UCD	Green Mountain	Eagle predation
90D1A	F314	F	8	03/16/2006	UCD	Crook Point	Unknown (not predation)

[1]UCD = UC Davis Veterinary Medical Teaching Hospital

Table 5. Reproductive success of captive San Miguel Island foxes, 2004-2005 breeding season.

Pen	PitTag	Sex	Age	Yrs Paired	Result	Pups Weaned	Pups Lost	Mast	Aggr	♂ Removed	Died
M01	87F53	M	3								
	85764	F	3	3	Litter	2					

Pen	PitTag	Sex	Age	Yrs Paired	Result	Pups Weaned	Pups Lost	Mast	Aggr	♂ Removed	Died
M02	52F0C	M	2						♂	5/29/05	
	52249	F	1	1	No Litter	0					
M03	7574A	M	7								
	92C32	F	7	6	Litter	2		M			
M04	93901	M	1								
	C5D00	F	1	1	No Litter	0					
M07	44829	M	7								
	90D1A	F	7	6	No Litter	0					
M08	5797C	M	2								
	53A78	F	2	1	No Litter	0	?	M			
M09	63E0F	M	1						♂		
	7534A	F	12	1	No Litter	0				5/7/05	
M10	C311C	M	2								
	F3164	F	1	1	No Litter	0					
M11	47B06	M	5								
	E2677	F	7	5	Litter	1		poss			
M12	E666D	M	2								
	B0B25	F	6	1	Litter	2					
M13	11F73	M	4								
	F6558	F	6	3	No Litter	0	?	poss			
M14	57150	M	7								
	60921	F	7	3	No Litter	0	2	M			4/9/05
M15	B0E36	M	3								
	B7E0A	F	3	2	No Litter	0	?				
M16	85D02	M	6								
	90C7D	F	2	1	No Litter	0	1	M			
M17	C7303	M	4								
	11929	F	5	4	Litter	2					
M18	C4A16	M	4								
	71071	F	6	4	Litter	1		poss			
M19	66C6E	M	3						♂	11/1/04	
	92804	F	13	1	No Litter	0					
M20	C111F	M	2								
	11F6C	F	1	1	No Litter	0	3	M			4/28/05
M22	91167	M	2								
	03A13	F	2	1	No Litter	0		M			

According to the recommendations of the AZA's population management plan for San Miguel island foxes (Lynch 2005a), new pairings were implemented for San Miguel island foxes in December 2005, after mate-choice attempts failed (see p. 15). Three existing pairs were broken up, and 5 new pairs were created (see Appendix B for island fox pairs currently in captivity on San Miguel, as well as pairings for the 2006 breeding season).

Table 6. Island fox pups born in captivity, San Miguel Island, 2005.

PIT Tag	Studbook Number	Sex	ID	Sire	Dam
B282A	275	F	M01	87F53	85764
F4C46	274	M	M01	87F53	85764
50572	267	M	M03	7574A	92C32
07541	266	M	M03	7574A	92C32
94714	268	M	M11	47B06	E2677
3167E	271	F	M12	E666D	B0B25
2033F	270	F	M12	E666D	B0B25
97036	273	F	M17	C7303	11929
30D5F	272	F	M17	C7303	11929
15A49	269	F	M18	C4A16	71071

Health/Medical

The primary health concern for San Miguel Island foxes in 2005 was the occurrence of mastitis, a bacteria-caused inflammation of the mammaries, among adult females during the breeding season. Mastitis was discovered by project veterinarian Dr. Winston Vickers as a result of examinations conducted in May 2005 after the deaths of 2 adult females in April (see below). Those 2 females lost litters (of 2 and 3 pups each) and 4 other females possibly lost litters as well (Table 5), as indicated by evidence of nursing (fur licked away from mammae, teeth marks on mammae) or by the presence of dead pups. In addition to the 2 females which died, mastitis was confirmed in 4 females by bacteria cultured from expressed milk. Upon confirmation of mastitis, all captive females were placed on antibiotics (Baytril or Amoxicillin) as a precaution.

Other health concerns discovered during the May exam were severe aggression-caused injuries to 2 females (52249 and 7534A) requiring extensive veterinary care and separation of pair members. Several females were deemed underweight and/or had inadequate body condition, and low calcium levels. To correct this, kibble was increased in all pens, and whole animal feed (deer mice and frozen quail) was increased to one whole animal per day in all pens with pups.

Mastitis indirectly caused the deaths of 2 adult female island foxes on San Miguel in 2005 (Table 4). Both females, each of which had just given birth, died of septicemia (bacterial infection) and showed evidence of mastitis (L. Munson, UC Davis, pers. comm.) Female 60921, a wild-born fox estimated to be at least 7 years old, died on April 9, 2005, shortly after giving birth to 2 pups, which did not survive. Preliminary necropsy

results indicate that, in addition to septicemia and mastitis, dystocia (difficult birth) was likely caused by a large colonic mass located near the pelvis, itself likely the result of *Spirocerca* infection (L. Munson, UC Davis, unpubl. data). Female 60921 tested positive for Spirocerca during parasite assays in 2001 and 2004. In island foxes *Spirocerca* can cause colonic granulomas which can result in prolapse, septicemia and other problems, and many San Miguel pens have tested positive for the parasite. In 2004, 60921, a potential founder that never bred in captivity, also gave birth to 2 pups which did not survive.

The second mortality also occurred in April 2005. Female 11F6C, born in April 2004, died on April 28, 2005, 3 days after giving birth to 3 pups, none of which survived. Just prior to her death 11F6C was emaciated (her weight was 1.7 kg; she had stopped eating after giving birth), hypothermic and non-ambulatory. Cause of death was determined to be septicemia, secondary to mastitis (L. Munson, UC Davis, pers. comm.).

In addition to mastitis, a variety of other factors may have contributed to the deaths of the two adult captive females, as well as to the apparent loss of other litters in spring 2005 (W. Vickers, Institute for Wildlife Studies, unpubl. data). The level of mate aggression seen in the pens may be attributable to the pens' relatively small size (500-700 ft^2) and the relative inability of females to escape male aggression. Having few, large denboxes may not have allowed the female to bear pups safely away from the male. Late and intense precipitation in spring 2005 caused denboxes to become saturated, which may have contributed to the occurrence of mastitis. As a result of these observations, breeding pens were expanded on San Miguel and Santa Rosa Islands in 2005, new denboxes were constructed, and additional shelters were provided. Regular (1-2 months) veterinary visits were scheduled in order to detect problems earlier.

Because foxes that contract mastitis may be prone to contract it again, island foxes will be closely monitored during the 2006 breeding season for signs of mastitis.

All captive San Miguel island foxes were given annual veterinary examinations by Dr. Mark Willett, D.V.M., in July 2005. At time of examination, blood samples were taken from all animals and processed by IDEXX Laboratories (Sacramento, CA) for hematology and complete blood chemistry. Injuries and other conditions requiring veterinary treatment are summarized in Appendix C. All captive foxes were vaccinated against canine distemper virus, and, for the first time, against rabies, upon the advice of project veterinarians.

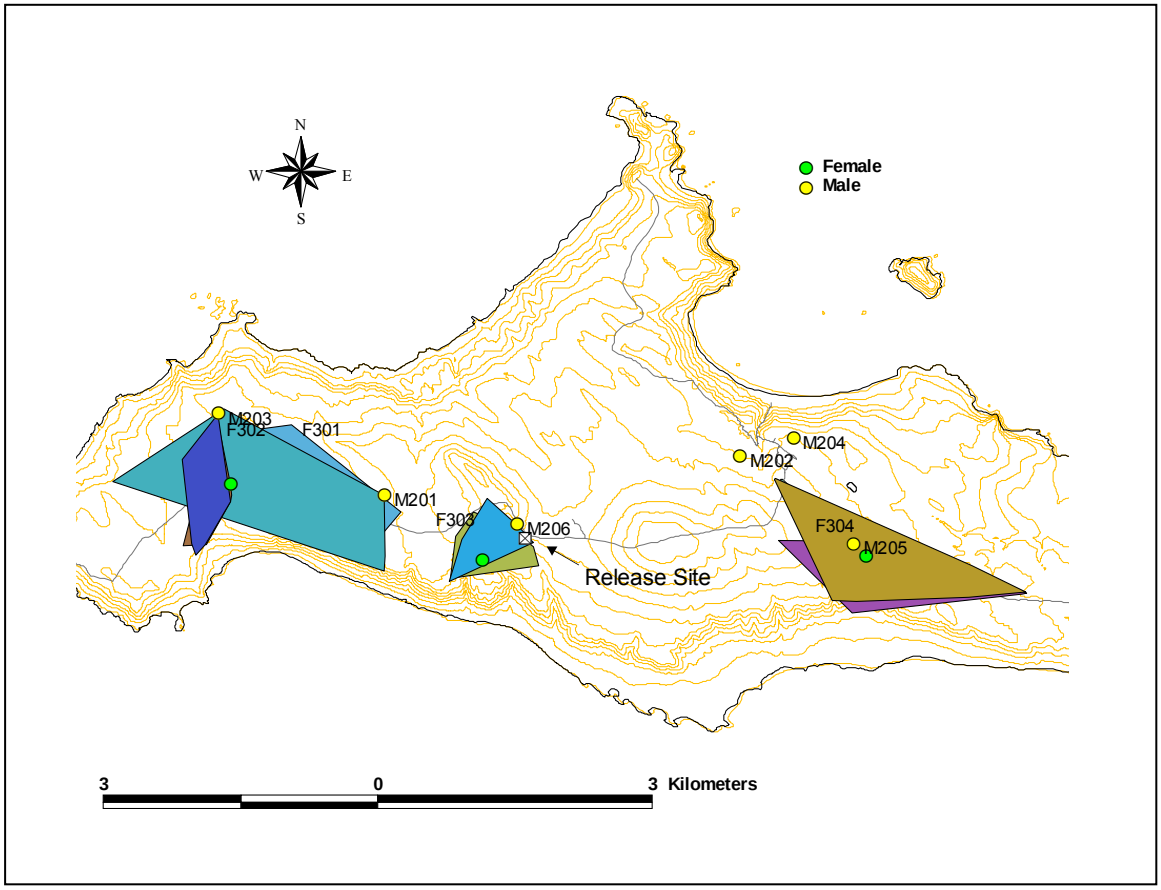

Figure 3. Breeding use areas of 4 island fox pairs, San Miguel Island, 2005.

Reintroduction of San Miguel Island Foxes

Foxes were first released back into the wild on San Miguel in fall 2004. Foxes had been absent from the island since 1999, when the remaining animals, save 1, were brought into captivity. The 10 foxes released in 2004 all survived through 2005. The 4 females released in fall 2004 all established breeding territories (Fig. 3) and produced litters in spring 2005, and a total of 10 wild-born pups (5 males, 5 females) were recruited into the population (Table 7). The reproductive success in the wild was surprising. All 4 of the Miguel females were released as juveniles (age = 0.5 yrs), and produced litters at 1 year of age. This rate of reproductive success is much higher than the rate of success for captive juvenile females. Of 10 pairings involving juvenile females in captivity, none produced litters (Coonan et al. 2005a). The rate of success is also higher than that recorded for wild juvenile females on San Miguel prior to and during the decline of the 1990s. In the wild on San Miguel in 1993-1998,

only 19% of 1-2 yr old females produced litters (Coonan et al 2005b).

Table 7. Island foxes born in the wild on San Miguel Island, spring 2005.

PitTag	ID	Sex	Collared	Died	Mortality Cause
25A63	F310	F	11/05/2005		
53E39	F311	F	11/19/2005		
C0934	F312	F	11/26/2005	01/29/2006	Predation
06125	F315	F	12/04/2005		
B3252	F316	F	12/04/2005		
87067	M217	M	12/04/2005		
46629	M218	M	12/04/2005		
22A35	M219	M	12/05/2005		
22A35	M222	M	12/23/2005		
B112A	M223	M	02/05/2006		

On the basis of this reproductive success, and the 100% survival of foxes released in 2004, the Recovery Coordination Group of the U. S. Fish and Wildlife Service' Island Fox Recovery Team recommended large releases for fall 2005 on San Miguel Island. Accordingly, the AZA's annual update of the San Miguel Island Fox population management plan (Lynch 2005a) recommended releasing 23 of the 48 foxes in captivity. One male slated for released escaped from captivity. Two animals (92804 and 7534A) were later considered to be non-releasable, due to age and physical condition. Twenty-one foxes (12 males, 9 females) were released to the wild between 14 October and 06 December, 2004, at a total of 7 release sites on San Miguel Island (Table 6).

As of 15 April 2005, 20 of the 21 released foxes were alive, with functioning radiocollars. Female 90D1A died near Crook Point on 16 March, 2006, of unknown causes. Her carcass was intact, indicating that the cause of death of death was not predation. The female fox was 8 years old and was one of the original 14 foxes brought into captivity in 1999. She and her mate in captivity, founder male 44829, had litters annually from 1999-2004 and produced a total of 12 pups. They did not produce a litter in 2005, and were released as a pair in December. They did not stay together after release. Examination of 90D1A's carcass suggested she had injuries incurred in agonistic interaction with other foxes. It is possible that at her age ($\geq$ 8 yrs) she did not compete well with younger foxes for a territory.

Table 8. Island foxes released to the wild, San Miguel Island, 2005.

PitTag	ID	Sex	Age	Born[1]	Date	Release Type[2]	Area	Fate
F4C46	M210	M	0	C	10/19/2005	P	Lester Point	In wild
B282A	F307	F	0	C	"	"	"	In wild
50572	M208	M	0	C	10/14/2005	S	Willow Canyon	In wild
63E0F	M211	M	1	C	10/20/2005	S	Lester Point	In wild
52F0C	M213	M	2	C	10/28/2005	S	Charcoal Canyon	In wild
90D1A	F314	F	7	W	12/05/2005	P	Cardwell Point	d. 3/16/06
44829	M216	M	7	W	"		"	In wild
53A78	F306	F	2	C	09/30/2005	P	Cardwell Point	In wild
5797C	M207	M	2	C	"	"	"	In wild
93901	M221	M	1	C	12/06/2005	S	Dry Lakebed	In wild
F3164	F313	F	1	C	12/01/2005	S	Lester Point	In wild
B7E0A	F308	F	3	C	11/27/2005	P	Devil's Knoll	In wild
B0E36	M212	M	3	C	"		"	"
C7303	M220	M	4	C	12/06/2005	F	Dry Lakebed	In wild
30D5F	F318	F	0	C	"		"	"
97036	F317	F	0	C	"		"	"
15A49	F309	F	0	C	10/22/2005	S	Lester Point	In wild
66C6E	M214	M	3	C	11/23/2005	S	Devil's Knoll	In wild
C111F	M209	M	2	C	10/29/2005	S	Charcoal Canyon	In wild
13212	M215	M	3	C	11/23/2005	S	Devil's Knoll	In wild
03A13	F305	F	2	C	7/30/2005	S	Cardwell Point	In wild
91167	--	M	2	C	06/15/2005	E	Brooks Canyon	In wild

[1]C = captive, W = wild
[2]P = pair, S = Single, F = family, E = escaped from captivity

One juvenile born in the wild in spring 2005 died from golden eagle predation on 29 January, 2006 (Table 4). Her mortality was the first recorded for radiocollared San Miguel foxes since initial releases began in fall 2004. Evidence for predation included degloving and evisceration. An adult golden eagle was observed in north Green Mountain Canyon, near to the mortality site, 2 days previous (D. Richards, National Park Service, pers. comm.). Two separate sightings of an unidentified eagle were reported for the San Miguel Hill area and north Green Mountain Canyon area on 30 January, 2006. Eagle researcher Peter W. Sharpe of the Institute for Wildlife Studies surveyed San Miguel Island for golden eagles from February 4-7 but observed no eagles.

Currently there are a total of 40 foxes (24 males, 16 females) in the wild on San Miguel (Fig. 4).

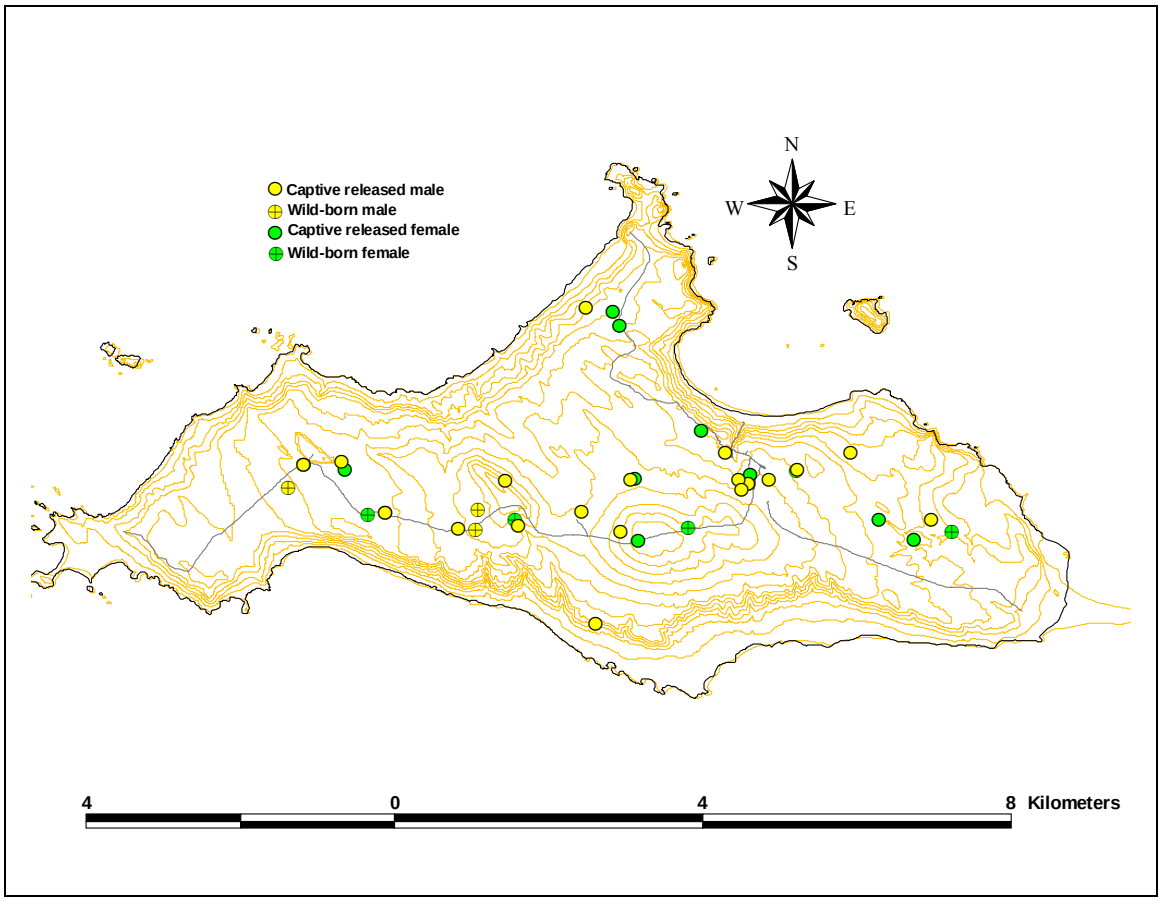

Figure 4. Recent locations of released and wild-born island foxes, San Miguel Island, January 2006.

Monitoring of Released and Wild Foxes

Released and wild island foxes are monitored using several techniques. First, all released foxes are radio-collared, as are any wild-born pups trapped during annual trapping, to monitor survival and mortality factors. Second, automated cameras are deployed near likely den sites to record the number of pups weaned from wild litters. Third, trap success rate can be calculated from results of annual cluster trapping, where areas known to be frequented by foxes are trapped in order to replace radiocollars and insert passive integrated transponder (PIT) tags and affix radio-collars to wild-born pups. Data collected via these methods are used to monitor fate of individual foxes, estimate reproductive success in the wild, and estimate relative abundance of wild foxes.

Methods

Prior to release each fox was outfitted with a 38-gram radio-collar (Advanced Telemetry Systems, Inc., Isanti, Minnesota; Holohil Systems Ltd., Ontario, Canada) fixed with a mortality sensor to allow for tracking, mortality monitoring, and potential recovery of animals from the field if necessary. Each released fox was tracked on a daily basis for the first month after release, three times per week during the second month, and then at least once per week for the remainder of the year following release. If a mortality signal was detected, the carcass was recovered as soon as possible and sent to the Veterinary Medical Teaching Hospital, University of California-Davis for necropsy. Foxes were determined to have died from golden eagle mortality based upon the following characteristics: evisceration, degloving of limbs, talon marks, and presence of eagle feathers and whitewash at the carcass site (Roemer et al. 2001a, Coonan et al. 2005).

Locations of radio-collared foxes were determined by triangulation with LOCATE II software (Pacer Computer Software, Truro, Nova Scotia) or by visual confirmation. Coordinates of each location were recorded with a geographic positioning system (GPS) device (Garmin International, Inc., Olathe, Kansas; or Thales Navigation Inc., Santa Clara, California). Likely den sites were identified when the locations of radio-collared females became consistent over a 2-week time period in one location during early to mid-April. Remote camera stations were then set up near known den sites in June-July (after pups had emerged from dens) to record the number of pups weaned from each litter. Each camera station included a box trap (23 X 23 X 66 cm, Tomahawk Live Trap Co., Tomahawk, Wisconsin), wired open and baited with dog kibble. A digital camera recorded fox activity in or near the trap when triggered by a passive infrared detector (Penn's Woods Products Inc., Export, Pennsylvania). Wild-born pups were trapped in early to mid-summer to determine sex and to mark them permanently with a passive integrated transponder (PIT) tag (Biomark, Seattle, Washington), and again in early fall when they had reached adult weight (>2.0 kg), to affix radio-collars.

Survival of radio-collared foxes was estimated with the non-parametric Kaplan-Meier procedure with staggered entry of foxes as they were released to the wild, and of wild-born foxes as they were radio-collared (Pollock et al. 1989). For an index of relative abundance, we calculated trapping success as the number of individual foxes trapped divided by the number of trap-nights.

Results

No foxes released on San Miguel Island in fall 2004 died in the subsequent year. One San Miguel fox released in fall 2005 died in March 2006 of unknown causes, and 1 of 10 radio-collared wild-born juvenile foxes died due to eagle predation in January 2006. Annual survivorship of San Miguel Island foxes from March 2004 – March 2005 was 94.0% (95% CI = 87.0 – 100%). This level of annual survivorship is greater than the 80% survivorship required for a stable or increasing population (Roemer et al. 2001b).

Automated cameras and direct observation detected a maximum of 10 pups in the 4 breeding territories (Table 9). Subsequent trapping detected 9 wild-born juveniles (Fig. 5). In addition, 1 dead unmarked pup was found in the Dry Lakebed territory on 15 July 2005. Blood samples were collected for the majority of the captured juveniles, and parentage should eventually be determined for those animals.

Table 9. Number of pups detected by automated cameras and direct observation for 4 breeding territories, San Miguel Island.

Territory	Female	Male	No. of Pups	Dates of Camera Survey
Dry Lakebed	F302	M203	2*	07/08 – 08/03
Jackass Flats	F301	M201	2	**
Green Mountain	F303	M206	4	06/26 – 07/24
Brooks Canyon	F304	M205	2	06/09 – 06-24

*1 pup on film, the other found dead

**no camera deployed; pup count is from direct observations of known (radio-collared) foxes with pups

During cluster trapping from July-December 2005, a total of 17 individual foxes were captured in 114 trap-nights, yielding a trap success rate of 14.9%. In comparison, trap success in 1999, when the remaining foxes were brought into captivity, was 1.6% (12 individuals in 718 trap-nights). Trap success in 1994 was 17.5% (154 individuals in 876 trap-nights).

At this point it is highly likely that all foxes in the wild on San Miguel are marked and all but 1 are radio-collared. Moreover, because there were only 4 females in the wild in spring 2005, it was possible to determine their likely denning areas and subsequently the number of pups in each area via automated cameras and cluster trapping. However, there are currently 16 females in the wild, and it will not be possible to ascertain breeding status for all of them in 2006, nor will it be possible to identify and trap all pups born in the wild.

Under these conditions tracking radio-collared foxes will continue to be an effective method to monitor survival and mortality causes, but estimating demographic parameters such as abundance, population size, density and recruitment for the expanding wild population will require sampling methods. From 1993-1999 the island fox population was monitored annually on San

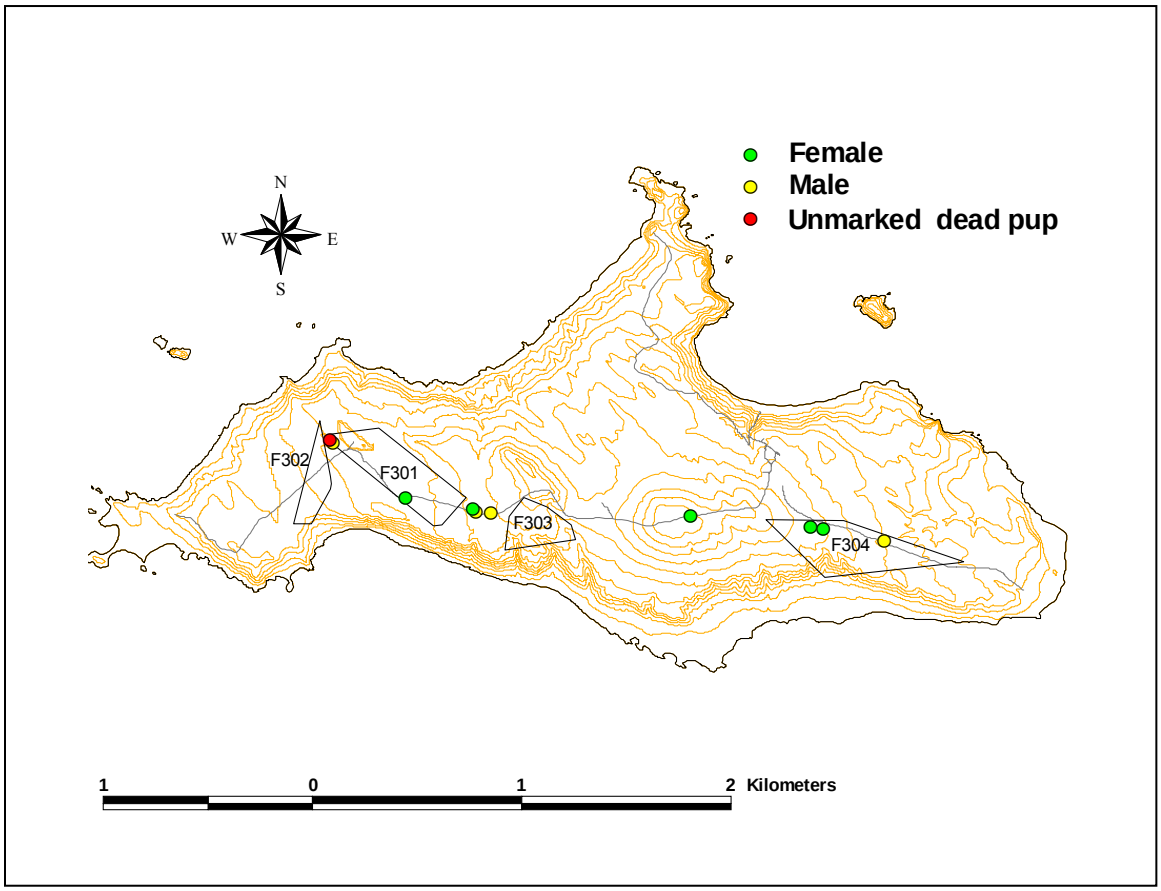

Figure 5. Capture locations of wild-born juvenile island foxes in relation to breeding territories, San Miguel Island, 2005.

Miguel Island via mark-recapture methods on 3 large (3.0 km^2) grids. The method returned high-quality data on density and recruitment (Roemer et al. 1994, Coonan et al. 2005c) but was cost and labor-intensive to implement, and worked best for high-density fox populations. In 2006 we will investigate the potential for two other methods to return population monitoring data without resorting to full-blown large grid monitoring.

First, we are collaborating with Melissa Gray and Dr. Robert Wayne of UCLA in investigating the potential for fecal genotyping as a population monitoring method for island foxes. Fox fecal samples will be collected along transects on San Miguel and Santa Cruz Islands, the locations recorded with GPS, and the fecal

samples identified to individual via microsatellite genotyping methods. Repeated sampling of a transect over several days will yield data that can be analyzed via mark-recapture methods and rarefaction curves to estimate the number of individuals in an area.

Second, small irregular grids will be trapped on San Miguel in summer 2006, and fox density will be estimated via program DENSITY (Efford et al. 2004). The grids will be smaller (18 traps) than those trapped during previous population monitoring (49 traps), will be trapped for 3 nights instead of the previous 6, and will be located along island trails. Thus one grid should be able to be effectively trapped per week-long island field tour by the current 2-person fox technician crew; previous population monitoring efforts required a crew of 4. Density estimates gained from the trapping will be compared to population numbers estimated from fecal genotyping, and with the known number of individuals in the area as determined by radiotelemetry.

Future Recovery Actions for San Miguel Island Foxes

Ten to 20 additional island foxes will be released in fall 2006, the number dependent upon the number of pups produced in captivity in spring 2006. Captive and wild pups born in 2006 will be PIT-tagged. All captive foxes will be given veterinary examinations, will have blood samples drawn for testing, will be vaccinated against canine distemper virus and rabies, and will be given veterinary treatment as required for injuries and other medical conditions. Foxes will be released to the wild under a release plan developed in summer 2006.

Captive breeding and annual releases may be required for a total of 10 years, until San Miguel Island foxes have reached a target population size (Coonan 2003) which insures the likelihood of persistence. Given current high rates of wild fox population increase on Santa Cruz ($\lambda = 1.3$; Garcelon et al. 2006) and high annual survival and reproductive success of recently released San Miguel Island foxes, the wild population on San Miguel might reach 300 foxes by 2012.

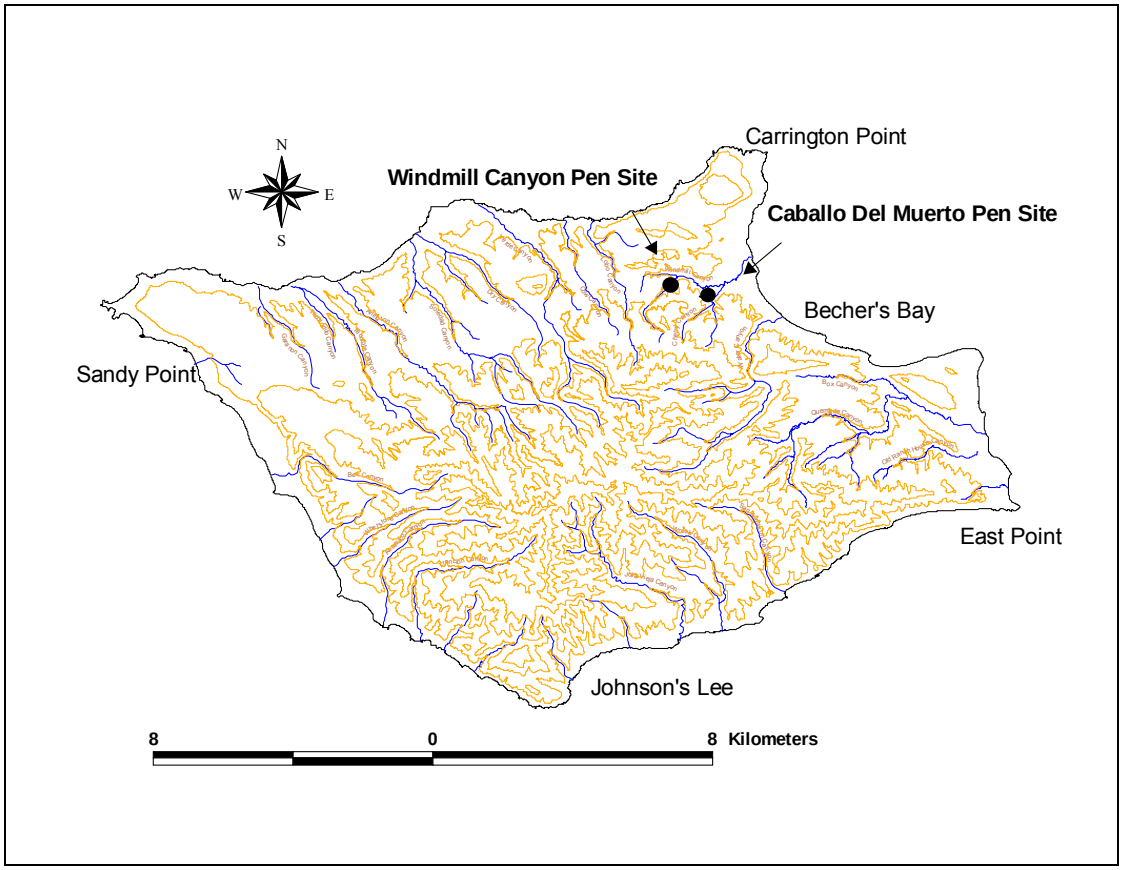

Figure 6. Location of island fox captive breeding facilities, Santa Rosa Island.

Recovery of Santa Rosa Island Foxes

With the birth of 8 pups in spring 2005, the captive island fox population on Santa Rosa Island grew to 51 foxes, of which 17 were released to the wild in fall 2005 (Table 10). After releases, 8 foxes had died as of 30 April 2006 (Table 11). Six Santa Rosa Island foxes died from eagle predation: 2 foxes released in fall 2005, 2 foxes released in fall 2004, and 2 juveniles born in the wild in 2005. Two other foxes died of unknown causes, but not predation. Nine pups were weaned from 3 wild litters in spring 2005. By April 2006 there were 32 foxes in the wild on Santa Rosa Island.

Captive Breeding

On Santa Rosa, 4 of 19 captive pairs (21%) produced litters in 2005 (Table 12), and of the 8 pups born in captivity in 2005, 6

were male (Table 13). No new founders bred in 2005, and the number of founders remained at 12. Ten captive-born and 5 wild-born females failed to produce litters in 2005. Six females lost litters and one other female possibly lost a litter. Two females which lost litters had mastitis, and 2 other females which lost litters possibly had mastitis. Two males were removed (from pens R08 and R03) in May 2005 due to aggression. No adult female died from mastitis.

Table 10. Growth of captive island fox population, Santa Rosa Island.

	Adults			Pups					Total
Year	F	M	Total	F	M	Total	Died	Released	Captive
2000	8	4	12[1]	5[2]	5[2]	10	0		22
2001	14[3]	9	23	7	3	10	1		32
2002	20	12	32	9	4	13	0		45
2003	29	16	45	6	5	11	0	7	49
2004	30	19	49	2	7	9	2	13	43[4]
2005	22	21	43	2	6	8	0	17	34

[1]Founding population
[2]Includes 8 pups born in captivity, and 2 pups (1 male, 1 female) born in the wild
[3]An additional female was brought in from the wild on 05/14/2001
[4]Includes 1 female pup born in the wild in spring 2004 and brought into captivity

Table 11. Island fox mortalities, Santa Rosa Island, 2005-2006.

PIT tag	Release ID	Sex	Age	Date	Specimen Depository[1]	Area	Mortality Cause
E5100	F115	F	4	01/22/2005	I	Black Mountain	Golden eagle predation
A045A	M03	M	3	02/05/2005	UCD	Becher's Bay ranch	Trauma; stuck in PVC pipe
51E3E	M05	M	3	03/30/2005	UCD	Verde Canyon	Golden eagle predation
10445	F117	F	4	11/19/2005	UCD	Signal Road	Golden eagle predation
60D24	M16	M	2	12/29/2005	UCD	Garanon Canyon	Unknown (not predation)
E1F30*	F127	F	0.5	2/1/2006	NPS	Trap Canyon	Golden eagle predation
53723	M17	M	3	2/1/2006	NPS	Chickasaw Canyon	Golden eagle predation
E3F0F	F128	F	4	2/9/2006	UCD	La Jolla Canyon	Golden eagle predation
53A3F*	F122	F	1	2/12/2006	UCD	Garanon Canyon	Golden eagle predation
2571A	F113	F	4	3/8/2006	UCD	La Jolla Canyon	Golden eagle predation
B7D38	F120	F	3	3/22/2006	UCD	Dry Canyon	Unknown (not predation)

[1]UCD = UC Davis Veterinary Medical Teaching Hospital, NPS = Channel Islands NP
I = Insufficient material for analysis
*denotes fox born in the wild in spring 2005, all others are captive-released animals

Table 12. Reproductive success of captive Santa Rosa Island foxes, 2004-2005 breeding season.

Pen	PitTag	Sex	Age	Yrs Paired	Result	Pups Weaned	Pups Lost	Mast	Aggr	♂ Removed
R01	80C3F	M	1							
	25D54	F	3	1	Litter	3				
R03	0507B	M	2						♂	5/17/05
	2410E	F	5	2	No Litter	0				
R04	53723	M	3							
	60B1D	F	4	3	No Litter	0				
R05	F0223	M	7							
	F4A18	F	6	5	Litter	1				
R06	F3D2F	M	4							
	63F2A	F	3	1	No Litter	0				
R07	70518	M	5							
	10030	F	7	5	No Litter	0	?	M		
R08	75125	M	4						♂	5/28/05
	95906	F	3	1	No Litter	0				
R09	84F28	M	5							
	A7954	F	2	1	No Litter	0				
R10	B067E	M	7							
	47304	F	3	1	Litter	3				
R11	73D0D	M	6							
	3512D	F	7	5	No Litter	0	?			
R12	47E09	M	2							
	A3B6D	F	1	1	Litter	1				
R13	37E00	M	5							
	96C2E	F	4	2	No Litter	0	4	poss		
R14	B7A6D	M	1						♂	
	E6D1E	F	4	1	No Litter	0				
R15	1271E	M	3							
	C7B1B	F	2	1	No Litter	0				
R16	C4F63	M	2							
	E3F0F	F	3	2	No Litter	0	L	M		
R17	9230A	M	1							
	A5E60	F	1	1	No Litter	0	L	poss		
R18	7235F	M	1							
	07061	F	7	1	No Litter	0	L			
R19	60D24	M	2							
	1612C	F	6	1	No Litter	0				
R20	85420	M	1							
	A180A	F	5	1	No Litter	0				

New pairings were implemented for the remaining captive Santa Rosa island foxes in December 2005, according to the recommendations of the AZA's population management plan for Santa

Rosa Island foxes (Lynch 2005b), after attempts at mate-choice trials failed (see p. 15). Nine existing pairs were broken up, and 11 new pairs were created (see Appendix B for island fox pairs currently in captivity on Santa Rosa Island, as well as pairings for the 2006 breeding season).

Table 13. Island fox pups born in captivity, Santa Rosa Island, 2005.

PitTag	Studbook Number	Sex	Pen	Sire	Dam
83149	300	M	R01	80C3F	25D54
E485E	299	F	R01	80C3F	25D54
D590E	298	F	R01	80C3F	25D54
25C14	301	M	R05	F0223	F4A18
64A43	304	M	R10	B067E	47304
32219	303	M	R10	B067E	47304
B6255	302	M	R10	B067E	47304
97541	305	M	R12	47E09	A3B6D

Health/Medical

As on San Miguel Island, the primary health concern for captive island foxes on Santa Rosa Island in 2005 was the occurrence of mastitis among breeding females (see p. 22 for a general discussion of mastitis among island foxes in 2005). Of the 6 females that lost litters in 2005, 2 had mastitis, and 2 possibly had it. Unlike on San Miguel, no adult Santa Rosa females died from mastitis in 2005. As on Miguel, all captive females were placed on antibiotics in May 2005 as a precaution, and food was increased to insure adequate nutrition. Because females that contracted mastitis in 2005 are prone to re-infection, breeding females will be monitored closely in spring 2006.

A number of other health concerns occurred in captive Santa Rosa Island foxes in 2005 (see Appendix C for a list of injuries and ailments requiring treatment). The most noteworthy is a condition that will require one of the captive foxes to be transferred permanently to a mainland institution. In October, male 37E00, a 5 yr-old wild-born fox captured in September 2000, was diagnosed with keratoconjunctivitis sicca (KCS) by Dr. Kristi Schmidt, DVM. Dry-eye syndrome, as it is also known, is characterized by the failure of the tear ducts to produce tears. Animals with KCS eventually lose their vision, and require twice-daily treatment with ophthalmic ointment and saline solution for comfort. Because the condition may be genetic, it is inappropriate for the fox to continue in the captive breeding program (he had failed to sire a litter in captivity). The consensus among project veterinarians was that 37E00 should be transferred to a mainland institution

where he could receive the required daily treatment. The USFWS approved the transfer in early 2006, and the Santa Barbara Zoo has agreed to take the animal, which will be transferred to the zoo when fecal parasite surveys are negative. A fecal assessment in March 2006 indicated the fox had *Spirocerca*, a parasite found only in island foxes and not on the mainland. The fox is currently undergoing treatment with doramectin to clear the parasite from its system.

In February 2005 a released fox was brought back into captivity temporarily to treat a prolapsed rectum. The condition was noted on February 14 by a fox technician conducting radiotelemetry monitoring of released foxes. The fox, M05 (51E3E) was captured overnight and brought to the foxpital on February 15, at which time surgery was conducted by Dr. Karl Hill, DVM, of the Santa Barbara Zoo. The fox received antibiotics and a special diet until 27 February, when it was released again to the wild.

All captive Santa Rosa island foxes were given annual veterinary examinations by Dr. Winston Vickers, D.V.M., in August 2005. At time of examination, blood samples were taken from all animals and processed by IDEXX Laboratories (Sacramento, CA) for hematology and complete blood chemistry. All captive foxes were vaccinated against canine distemper virus, and, for the first time, against rabies, upon the advice of project veterinarians.

Reintroduction of Santa Rosa Island Foxes

In fall 2003 foxes were first released back into the wild on Santa Rosa, where they had been missing since 2000, when the remaining animals were brought into captivity. A second release, of 13 foxes, occurred in fall 2004. Five of the 13 foxes died

Table 14. Pups born in the wild on Santa Rosa Island, spring 2005.

PitTag	ID	Sex	Collared	Died	Mortality Cause
53A3F	F122	F	10/15/2005	2/12/2005	Predation
13737	F121	F	10/7/2005		
3581A	F130	F	05/06/2006		
E1F30	F127	F	11/23/2005	2/1/2006	Predation
E7E64	F129	F	01/12/2006		
C5B32		F			
7145F	M14	M	10/31/2005		
26210	M15	M	11/4/2005		
B7F1A	M20	M	01/13/2006		

from golden eagle predation between November 2004 and April 2005. Although the number of deaths due to predation exceeded the threshold at which foxes would be returned to captivity, U. S. Fish and Wildlife Service advised the park not to recapture foxes, due to possible impacts on breeding females. A total of 3 females bred in the wild in spring 2005, producing 9 pups (3 males, 6 females) which were recruited into the wild population (Table 14). Eight of the 9 pups were recaptured and radiocollared, and 2 of the 8 died from eagle predation in February 2006.

Table 15. Island foxes released to the wild, Santa Rosa Island, 2005.

PitTag	ID	Sex	Age	Born[1]	Date	Release Type[2]	Area	Fate
52E0D	F119	F	2	C	10/01/2005	S	Quemada Canyon	In wild
B7D38	F120	F	2	C	10/01/2005	S	Quemada Canyon	Died 3/22/2006 of unknown causes (not predation)
84F28	M11	M	5	C	10/13/2005	S	Quemada Canyon	In wild
F3D2F	M12	M	4	C	10/20/2005	P	Clapp Springs	In wild
63F2A	F123	F	3	C	10/20/2005	"	"	In wild
E6D1E	F124	F	4	C	10/29/2005	P	Clapp Springs	In wild
B7A6D	M13	M	1	C	10/29/2005	"	"	In wild
C7B1B	F125	F	2	C	11/13/2005	S	Johnson's Lee	In wild
60D24	M16	M	2	C	11/13/2005	S	Johnson's Lee	Died 12/29/2005 of unknown causes (not predation)
60B1D	F126	F	4	C	11/18/2005	P	Johnson's Lee	In wild
53723	M17	M	3	C	11/18/2005	"	"	Died 2/1/2006 of eagle predation
75125	M02	M	4	C	11/20/2005	P	China Camp	In wild
95906	F103	F	3	C	11/20/2005	"	"	In wild
0654E	M18	M	5	C	11/23/2005	S	China Camp	In wild
E3F0F	F128	F	3	C	11/23/2005	S	China Camp	Died 2/9/2006 of eagle predation
83149	M19	M	0	C	11/25/2005	S	Carrington	In wild
25C14	M10	M	0	C	11/26/2005	S	Quemada Canyon	In wild

[1]C = captive, W = wild
[2]P = pair, S = Single

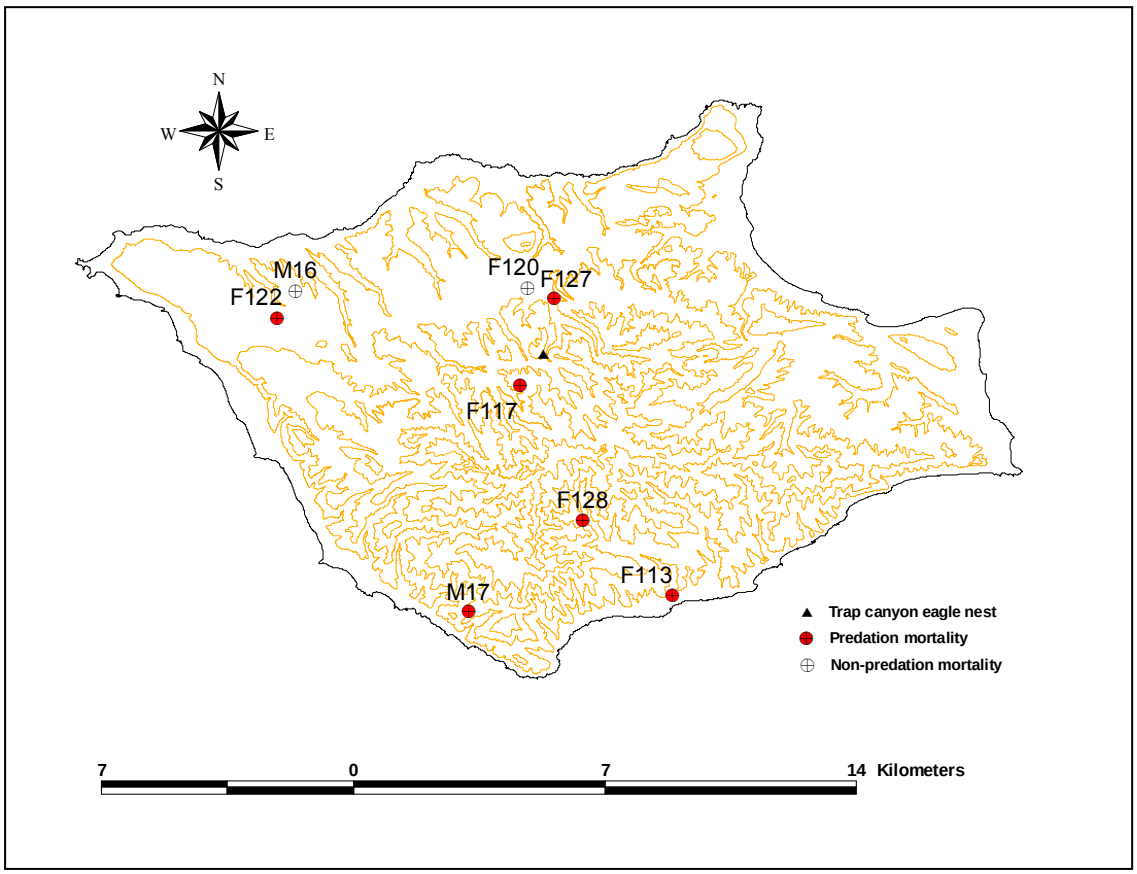

Figure 7. Mortality locations for released and wild-born island foxes on Santa Rosa Island, November 2005 - March 2006.

Seventeen foxes (9 males, 8 females) were released to the wild between 01 October and 26 November, 2004, at a total of 5 release sites on Santa Rosa Island (Table 15). Several of the release sites were located in the southern portion of the island, in order to encourage fox use of that underutilized area. Four of the released foxes died, 2 from eagle predation and 2 from unknown causes that were not predation (Fig. 7).

As in previous releases, there was considerable dispersal from the release sites. Dispersal distance was calculated as the distance between the release site and the latest location. Average dispersal distance for 7 females and 4 males was 5.9 km and 6.7 km, respectively. Foxes are currently dispersed over the island, though the southeastern quadrant of the island is still sparsely populated (Fig. 8).

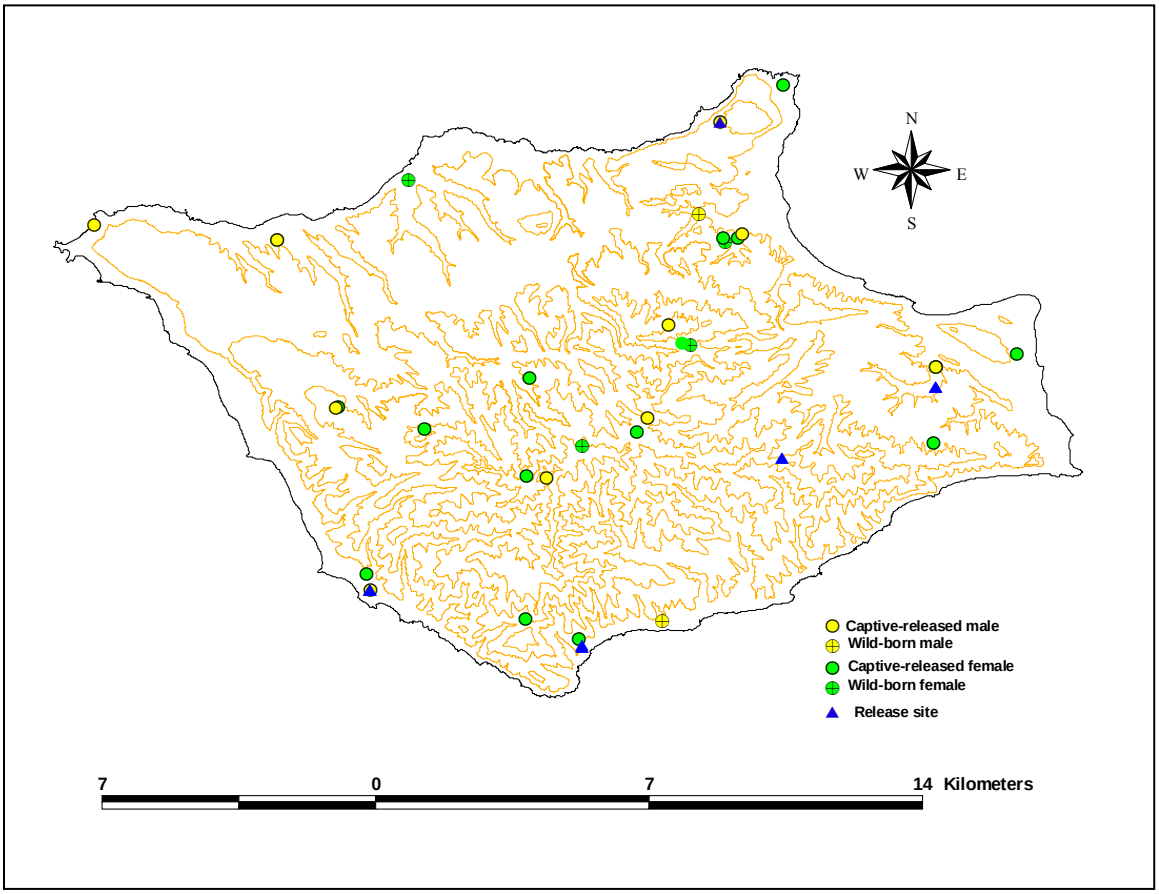

Figure 8. Recent locations of island foxes on Santa Rosa Island, January 2006.

After releases occurred in fall 2005, a total of 6 foxes died from eagle predation (Fig. 7), including 2 of the 2005 releasees (M17 and F128), 2 foxes released in 2004 (F113 and F117) and 2 pups born in the wild in 2005 (F122 and F127). Recent releasees have heretofore been thought to be the most vulnerable to eagle predation, but these recent mortalities suggest otherwise.

Two of 8 wild-born radio-collared juveniles died of predation on Santa Rosa Island, as did 1 of 10 radio-collared juveniles born on San Miguel Island. Previous work suggests that juvenile island foxes have lower survivorship than older foxes (Coonan 2005).

The monthly distribution of eagle-caused fox mortalities on Santa Rosa and San Miguel Islands (Fig. 9) suggests that foxes are most vulnerable to predation in late fall and winter. No mortalities

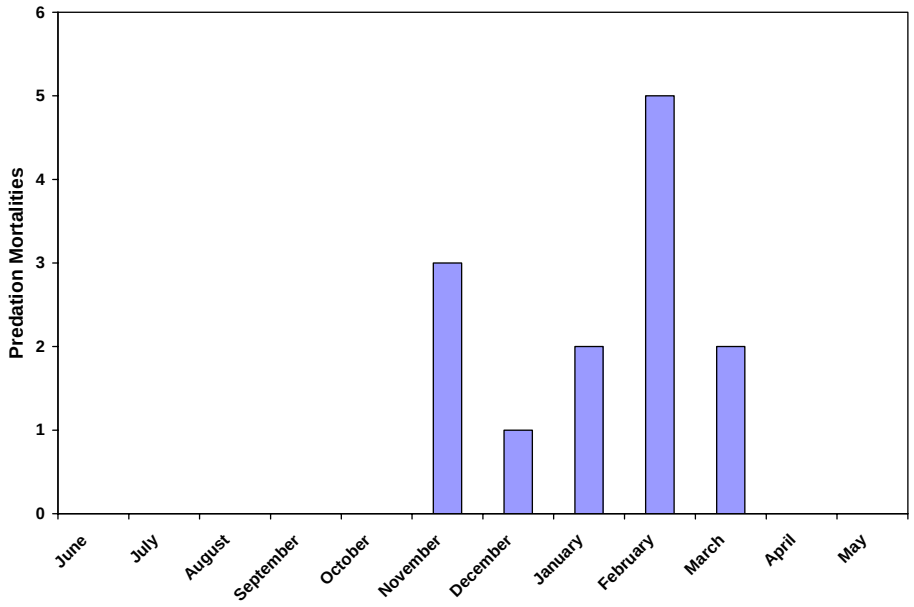

Figure 9. Monthly distribution of predation mortalities for island foxes on Santa Rosa and San Miguel Islands, 2004-2006.

have occurred between April and October. This seasonality may be due to three factors. First, eagles wintering on the islands may be attempting to build up energetic reserves required for breeding. Second, eagles may be attracted to the island by the availability of carcasses from the annual hunt and cull of deer and elk on Santa Rosa Island. Third, island foxes released in October and November do not establish home ranges until a month or two after release, and may be most vulnerable to predation until they do so.

Currently there are a total of 32 foxes (14 males, 18 females) in the wild on Santa Rosa.

Monitoring of Released and Wild Foxes

Monitoring methods are the same as previously described for San Miguel Island (p. 27).

Annual Kaplan-Meier survivorship of Santa Rosa Island foxes from March 2004 – March 2005 was 73.0% (95% CI = 59.0 – 87.0%). Annual survivorship was higher than that for the previous year (50.0%; 95% CI = 32.0 – 69.0%) but did not meet the 80% threshold required for a stable or increasing population (Coonan 2003). Eagle predation accounted for 6 of the 8 island fox mortalities

that occurred in the wild after foxes were released in fall 2005. No golden eagles bred on Santa Rosa in 2006 (P. Sharpe, Institute for Wildlife Studies, unpubl. data), marking the first year they had not done so since 1996 or 1997 (Latta et al. 2005). Still, the presence of several non-territorial golden eagles on Santa Rosa in winter 2005/2006 resulted in a level of predation sufficient to prevent the wild fox population from attaining the target annual survivorship of 80%.

A total of 8 pups were recorded by automated cameras deployed in 4 breeding territories (Table 16). No pups were recorded for one of the pairs (M06-F111/F108) in the Skunk Point/Torrey Pines area). Subsequent trapping detected 9 wild-born pups (Table 14). Blood samples taken from these captured pups may eventually be used to determine parentage.

At the suggestion of the U. S. Fish and Wildlife Service and the Island Fox Recovery Coordination Group, we established feeding stations near the likely den sites for the 4 females thought to be pregnant, in order to minimize the need for extensive foraging, which may have rendered them more vulnerable to predation.

Table 16. Number of pups detected by automated cameras for 4 breeding territories, Santa Rosa Island.

Territory	Female	Male	No. of Pups	Dates of Camera Survey
Ranch	F118	M09	3	06/08 – 06/24
Verde Canyon	F106	?[1]	2	06/24 – 08/11
Skunk/Torrey	F111/F108	M06	0	06/09 – 08/28
Soledad	F104	M08	3	07/06 – 07/21

[1]Likely mate M05 died due to eagle predation on 03/30/2005

During cluster trapping from June-November 2005, a total of 21 individual foxes were captured in 201 trap-nights, for a trap success rate of 10.4%. This is comparable to the trap success rate on San Miguel in 2005 (14.9%), and is much higher than trap success rate in 2000 on Santa Rosa, when foxes were initially brought into captivity. At that time, 16 individuals were captured in 1,014 trap-nights, for a trap success rate of 1.6%.

Future Recovery Actions for Santa Rosa Island Foxes

Ten to 20 additional island foxes will be released in fall 2006, provided that eagle predation does not force implementation of contingency measures, and provided that pup production in spring

2006 is adequate. Pups born in 2006 will be PIT-tagged. All captive foxes will be given veterinary examinations, will have blood samples drawn for testing, will be vaccinated against canine distemper virus and rabies, and will be given veterinary treatment as required for injuries and other medical conditions. Foxes will be released to the wild under an annual release plan developed in summer 2006.

It is estimated that captive breeding and annual releases will continue for another 6-8 years, until Santa Rosa island foxes have reached a target population size and survival rate (Coonan 2003) which insures a high likelihood of persistence.

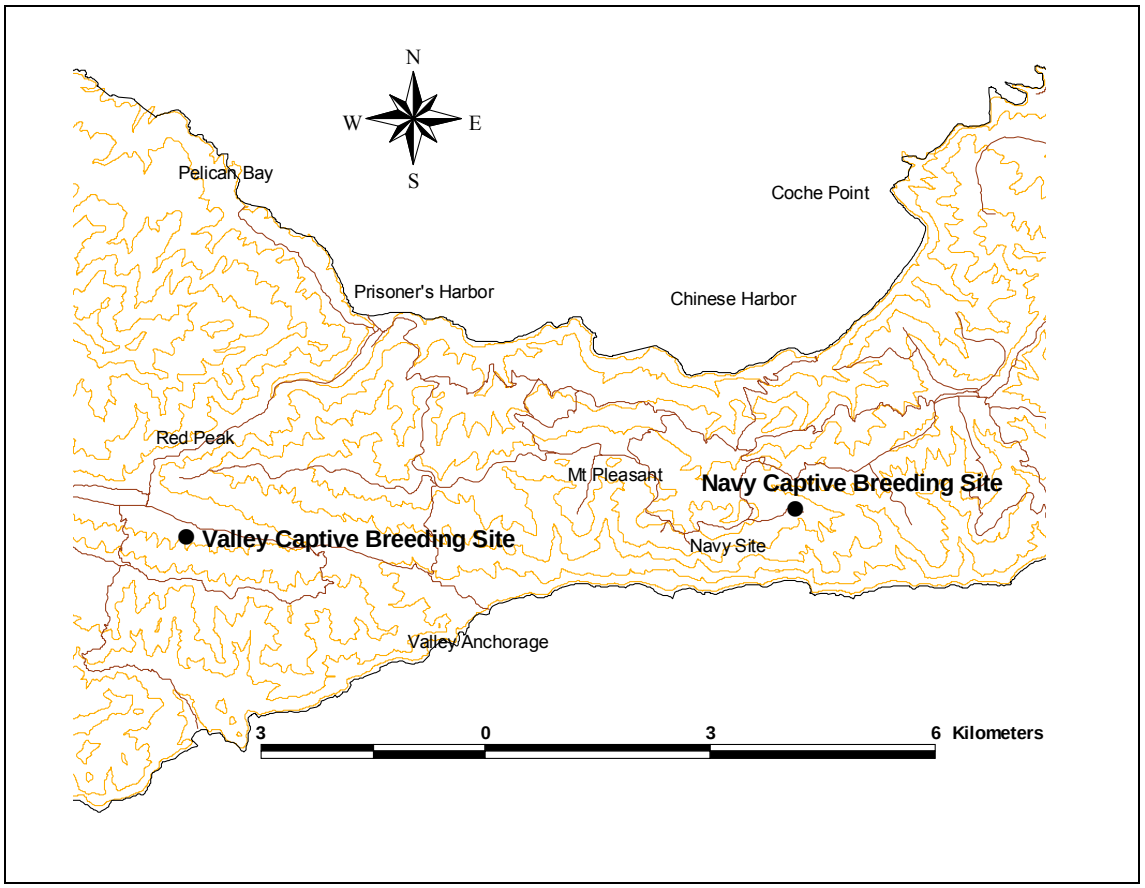

Figure 10. Location of island fox captive breeding facilities, Santa Cruz Island.

Recovery of Santa Cruz Island Foxes

The captive island fox population on Santa Cruz Island grew to 62 foxes in spring 2005 with the addition of 20 pups (Tables 16 and 17). One captive fox died during 2005, of abdominal bleeding and

trauma to the liver. No foxes were released to the wild in 2005. By the end of 2005 over 70 radiocollared wild foxes were being monitored in the wild, and annual survivorship of wild foxes remained at over 80%.

Captive Breeding

Ten of 21 pairs (48%) produced litters in 2005. Eight of the 11 females which did not produce litters were either juveniles (1 yr old) or had been paired for only one season. Of the 20 pups born in captivity, 12 were male, and the current sex ratio in captivity is 30M:31F. One new founder, male 1415A, bred in captivity in 2004, bringing the total number of founders for the Santa Cruz captive population to 16. There is one additional potential founder, female 0786F, which has not produced a litter. Unlike on San Miguel and Santa Rosa Islands, the number of founders could be increased on Santa Cruz Island by bringing additional wild foxes into captivity.

New pairings were implemented for Santa Cruz island foxes in December 2005, according to the recommendations of the AZA's population management plan for island foxes, after attempts at mate choice trials failed (see p. 17). One existing pair was broken up, and 11 new pairs were created. For the 2005-2006 breeding season there were 30 pairs (see Appendix B for a list of current pairs in captivity on Santa Cruz).

Table 17. Reproductive success of captive Santa Cruz Island foxes, 2004-2005 breeding season.

Pen	PitTag	Sex	Age	Years Paired	Result	Pups Weaned
C01	A4628	M	8			
	30B2D	F	6	3	Litter	1
C02	A6D41	M	5			
	D2C13	F	5	3	Litter	3
C03	A4F4C	M	1			
	0786F	F	7	3	No Litter	
C04	B506A	M	5			
	71B0E	F	5	2	Litter	2
C05	36172	M	6			
	72901	F	5	3	Litter	2
C06	86B1A	M	5			
	86F17	F	5	3	Litter	3
C07	45411	M	5			
	D2210	F	4	3	Litter	3
C08	96A5A	M	1			
	44D52	F	2	2	No Litter	
C09	1783E	M	8			

Pen	PitTag	Sex	Age	Years Paired	Result	Pups Weaned
	87035	F	7	3	Litter	3
C10	C480E	M	1			
	D3035	F	2	2	No Litter	
C13	B0C69	M	1			
	B365F	F	1	1	No Litter	
C14	9282E	M	1			
	C3262	F	1	1	No Litter	
C15	24063	M	1			
	6517A	F	1	1	No Litter	
C17	C3E7E	M	2			
	1784B	F	1	1	Litter	1
C18	1415A	M	5			
	F7C1D	F	1	1	Litter	1
C19	D0926	M	3			
	F7727	F	1	1	No Litter	
C21	87A65	M	1			
	03042	F	1	1	No Litter	
C22	F3F0E	M	2			
	16C30	F	4	1	No Litter	
C23	02361	M	2			
	E250C	F	2	1	Litter	1

Table 18. Island foxes born in captivity, Santa Cruz Island, 2005.

PitTag	Studbook Number	Sex	Pen	Sire	Dam
F0E3A	282	F	C01	A4628	30B2D
80810	283	M	C02	A6D41	D2C13
D010A	284	M	C02	A6D41	D2C13
0420A	285	M	C02	A6D41	D2C13
61902	286	M	C04	B506A	71B0E
61E2E	287	F	C04	B506A	71B0E
4112D	296	M	C05	36172	72901
5775A	297	F	C05	36172	72901
87276	290	M	C06	86B1A	86F17
27222	289	F	C06	86B1A	86F17
B675D	288	F	C06	86B1A	86F17
A2128	291	M	C07	45411	D2210
1277C	292	M	C07	45411	D2210
85A5C	293	F	C07	45411	D2210
84F7E	307	M	C09	1783E	87035
6360F	308	M	C09	1783E	87035
57263	309	M	C09	1783E	87035
06C60	294	F	C17	C3E7E	1784B
24F10	310	F	C18	F7C1D	1415A
55D2C	295	M	C23	02361	E250C

Health/Medical

One island fox died in captivity on Santa Cruz Island in 2005. Male D0926, a 3-year old male born in captivity, died on 19 December, 2005. A necropsy performed by Dr. Linda Munson of the University of California's Wildlife Health Center determined that the cause of death was abdominal bleeding and trauma to the liver. Prior to its death, the fox was thought to have kidney disease. During annual vet exams in July, Dr. Winston Vickers, DVM, found the fox to have reduced renal function, possible infection, and low blood albumin (protein) levels. A kidney biopsy performed in early December found evidence of glomerulonephritis and renal hypoplasia. However, the actual cause of death apparently was an unidentified physical injury to the liver area.

Santa Cruz foxes were less affected by mastitis and mate aggression during spring 2005 than foxes on San Miguel and Santa Rosa Islands. Examination by Dr. Winston Vickers, DVM, in May 2005 indicated that no females had mastitis, and 2 pens had evidence of mate aggression that prompted removal of the adult male from the pen.

Captive Santa Cruz Island foxes received veterinary examinations from project veterinarian Winston Vickers, DVM, in July 2005. Routine general physical examinations were performed in a nose to tail fashion, and included otoscopic examination. Blood samples were obtained from all animals for complete blood chemistry analysis. Foxes were generally in good or excellent health. Two foxes had injuries due to mate aggression. Two adults and two pups had ringworm fungal infections, associated with heavy flea and lice infestation. All captive foxes were vaccinated against canine distemper virus with a Canary pox vectored recombinant vaccine (Purevax Ferret Distemper vaccine, Merial, Inc., Athens, GA), and, for the first time, against rabies (IMRAB 3 rabies vaccine, killed virus, Merial Ltd., Athens, GA). Island foxes are normally vaccinated during annual veterinary examinations. Due to a nationwide shortage of the vaccine, island foxes were vaccinated in December 2005.

Reintroduction of Santa Cruz Island Foxes

No foxes were released from captivity on Santa Cruz Island in 2005.

Future Management of Santa Cruz Island Captive Foxes

The 30 pairs currently in captivity are likely to produce 30-40 pups in spring 2006, increasing the captive population to as many as 90-100 foxes. Current capacity is 30 pairs, or 60 foxes. The Institute for Wildlife Studies has developed a release plan for 2006 that would release as many as 50-60 foxes to the wild. The release would occur in three stages. Pairs which failed to breed would be released beginning in May 2006. Family groups and juveniles would be released in early and late fall, respectively.

Status of Wild Fox Population

The survivorship of radio-collared foxes on Santa Cruz Island is a measurement of the relative success of eagle removal in reducing predation as a mortality factor. Since December 2000, the Institute for Wildlife Studies has conducted monitoring of the Santa Cruz wild fox population via radiotelemetry. The number of foxes monitored increased over the study period from approximately 20 in 2000 to over 70 in 2004 (D. Garcelon, Institute for Wildlife Studies, unpubl. data).

From December 2000 through March 2006, golden eagle predation was identified as the cause of mortality for 37 (72%) of 51 foxes that died in the wild (D. Garcelon, Institute for Wildlife Studies, unpubl. data).

Over the study period wild fox mortality due to golden eagles declined, and annual survivorship of wild island foxes increased from 61% to over 90% in 2004 (Coonan et al. 2005a, 2005b), likely due to removal of golden eagles, and is currently over 80% (Fig. 7). Annual survivorship of 80% is the level determined by demographic modeling to be necessary for a stable or increasing fox population (Coonan 2003, Roemer et al. 2001). Survivorship in 2005 (83%, 95% CI = 75-91%) approximated island fox survivorship values recorded prior to the decline of island foxes (83%; Roemer 1999).

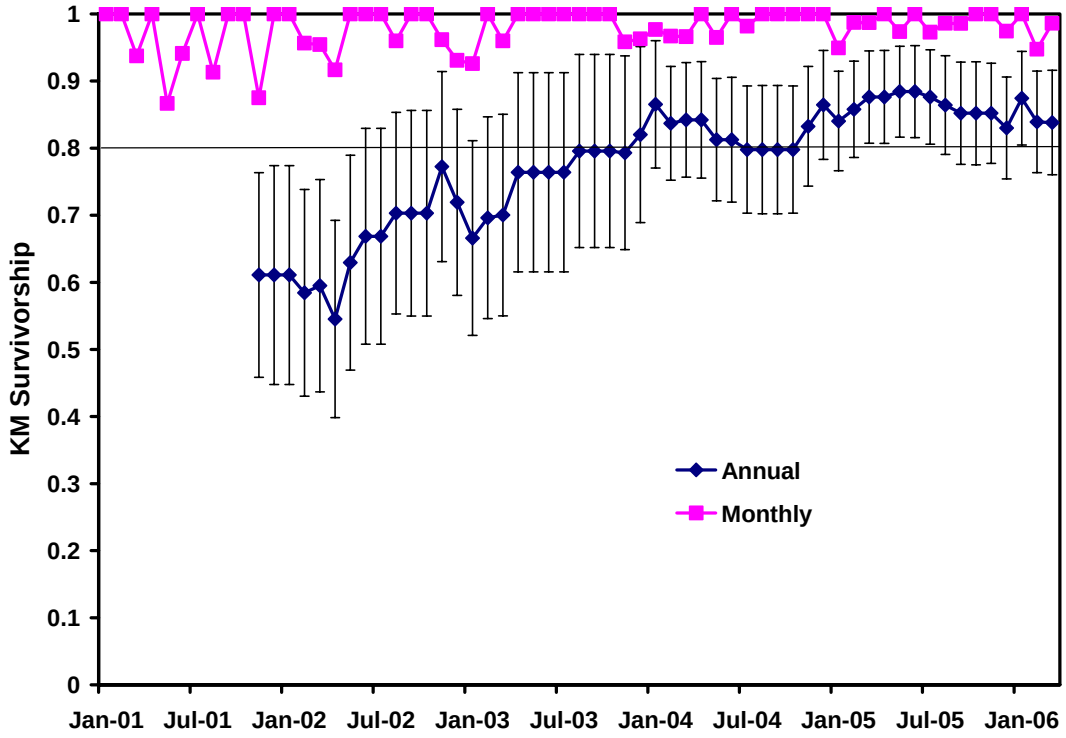

Figure 11. Annual and monthly Kaplan-Meier survivorship for wild island foxes, Santa Cruz Island, 2001-2006.

Removal of Golden Eagles

In 2005 NPS and TNC contracted with the Institute for Wildlife Studies (IWS) for survey and live-capture of golden eagles on the northern Channel Islands, following a 5-year effort by the Santa Cruz Predatory Bird Research Group (Latta 2005). A total of 4 golden eagles (1 adult male, 1 juvenile female, and 2 nestlings) were removed from the islands in 2004, bringing the total removed over since 1999 to 41 eagles (Fig. 8). Males comprised the bulk (21) of the 31 non-hatchling eagles removed. As few as 5 eagles remained on the islands at the end of 2005. The remaining birds included a pair of adults on Santa Cruz, an adult female on Santa Rosa, and 3 subadult eagles.

Removal Methods

In 2005 NPS established a cooperative agreement with IWS for relocation of golden eagles from the northern Channel Islands, and split the costs of golden eagle management with TNC, which established a contractual relationship with IWS for eagle

management. Including the costs of eagle management in 2005 (approximately $365,000), the total cost of eagle removal over the 6 year period was over $1,136,000.

The primary technique used for eagle capture was a dug-in, radio-controlled bownet placed in areas that eagles frequented (Jackman et al. 1994). Bait used included dead feral pigs, live feral pigs, and live rabbits. In a typical set, the bownet was set in place prior to dawn. If an eagle alighted on the prey, the net was deployed via radio signal from a distant hidden observation point. Captured eagles were banded and measured, and transported in large commercial sky kennels modified for raptor transport. Most captured eagles were flown off the island by the morning following capture, and then driven or flown by commercial airliner and driven to one of several release sites, east of the Sierra Nevada range. Releases occurred usually within 24 hours of capture.

Three other capture techniques were used during 2005. First, a dho-gaza net was used with a lure eagle near golden eagle nest sites. A dho-gaza is a thin, lightweight net set up in front of a tethered raptor, whose presence is likely to provoke an attack by a nesting golden eagle. A second capture technique is the nest-net, in which a net is bunched up below an eagle nest when the adult is away, and attached by cable and pulleys to a pull-line. When the eagle returns to incubate eggs or feed nestlings, the net is drawn up quickly over the nest and the eagle. The last technique was an “injecto-egg”, which is a plasticine egg in which has been placed a syringe with a sedative, attached to a gas-powered, remotely-tripped cylinder. Sedative is delivered to an incubating bird via radio signal which causes the syringe to inject and then retract back into the egg. The bird would then be hand-captured at the nest site.

Eagle nest sites during the breeding season offer the best potential for eagle capture, due to the investment of the parents in the breeding attempt and their need to provide growing hatchlings with food. Within the breeding season, the optimal time to attempt capture is when the hatchlings are at least 3 weeks old. At this age their food requirements are high, insuring that adults are prone to hunt and therefore likely to visit baited trap sites. Additionally, the hatchlings are large enough to thermoregulate on their own and can survive long periods of adults being away from the nest. Moreover, eagles disturbed during incubation will abandon more readily than will eagles disturbed (for example, by trapping attempts) during the hatchling phase. For these reasons, most capture attempts occurred during the nestling phase, although the nest-net and the injecto-egg can be used during incubation.

Results of 2005 Removal Efforts

Since 1999 golden eagles have used at least 10 different breeding territories, 8 on Santa Cruz and 2 on Santa Rosa. In 2005 eagle nesting attempts reached the incubation phase at 2 nests: the Christy/Watertank territory on Santa Cruz, and the Trap Canyon territory on Santa Rosa. Attempts to capture the Christy/Watertank birds via bownet, dho-gaza and injecto-egg during the incubation phase all failed, and the pair eventually abandoned their breeding attempt. The adult male from the Trap Canyon pair was captured on May 7. Bow-net and nest-net attempts to capture the adult female were halted on May 14 when it was suspected that the female had abandoned her 2 chicks. The two eaglets were then hand-captured at the nest.

Thus in 2005, the adult male was captured from one breeding pair (Trap Canyon) and at least one intact adult pair remained, at Christy/Watertank.

Future Plans for Eagle Removal

Because golden eagles remaining on the islands represent a threat to wild foxes and to foxes released from captivity, eagle removal efforts will continue in 2006, funded by The Nature Conservancy and NPS. Future eagle removal efforts will focus on removal of adult nesting females. Breeding females have proved difficult to capture. Only 4 breeding females were captured in the 5-year period, compared to 13 breeding males. In several cases where the male member of a breeding pair was captured, the female successfully bred the following year with a new male (Latta 2005).

Golden Eagle Prey Remains Study

The ability of golden eagles to breed and roost on the islands depends upon food availability. Availability of some prey will change in the short-term. For example, feral pigs are currently being removed from Santa Cruz Island. On Santa Rosa Island, over 400 non-native mule deer (*Odocoileus hemionus*) and 700 elk (*Cervas elephus*) provide both carcasses and live prey (fawns and calves) for golden eagles, but both those ungulate species will be removed by 2011 according to the terms of a negotiated settlement (National Park Service 1997). If those non-native ungulate species provide significant food resources for golden eagles, then their removal should reduce the ability of the islands to support golden eagles.

To determine the relative importance of various native and non-native prey species to golden eagles, Paul Collins of the Santa Barbara Museum of Natural History and Brian Latta of the Santa Cruz Predatory Bird Research Group conducted a study of prey remains found in golden eagle nests on Santa Cruz and Santa Rosa Islands, with NPS funding. Their results (Collins and Latta 2006) indicated that nesting golden eagles on Santa Cruz and Santa Rosa were supported by feral pigs and mule deer, respectively. Feral pigs were the most common prey item in the 4 Santa Cruz nests, comprising 59.1% of the eagle diet by biomass. On Santa Rosa Island, mule deer fawns comprised 34.6% of the eagle diet in the 4 nests excavated on that island. Island fox remains were found in the lower levels of the Santa Rosa nests, indicating that the nests were active prior to the removal of foxes from the wild for captive breeding in 2000. Based on the number of layers, it is estimated that golden eagles began breeding on Santa Rosa in 1996.

Other Actions Required for Recovery

The immediate actions required for island fox recovery are captive breeding of island foxes and removal of golden eagles. Additional, longer term actions required for island fox recovery (Coonan 2003) include removal of pigs from Santa Cruz Island, and reintroduction of bald eagles to the northern Channel Islands. The former is required to remove an alien prey base that supports golden eagle use of the islands, and the latter is required to return bald eagles to their former role as apex predator in the system. It is possible that breeding bald eagles may deter future golden eagle use of the islands.

Removal of Feral Pigs from Santa Cruz Island

With environmental compliance and planning completed (NPS 2002) and funding secured from both The Nature Conservancy and the NPS, a contractor was selected by TNC in 2004 and pig removal efforts began in early 2005. Removal of pigs should be completed by 2007, and the majority of the pigs may be removed very quickly, perhaps by summer 2006. As of May 2006, over 5,000 pigs had been removed from over 80% of the island. As soon as summer 2006 the relative impact of pigs on the island environment could be negligible, for the first time since the mid-19th century.

Reintroduction of Bald Eagles to the Northern Channel Islands

In 2002, the Institute for Wildlife Studies began a feasibility study to determine if bald eagles could be successfully reintroduced to the northern Channel Islands. The study is funded by settlements monies from the Montrose Settlements Restoration Program (NOAA et al. 2002), because the disappearance of bald eagles from the Channel Islands in the mid-20th century was due to the effects of organochlorine contaminants in the marine ecosystem of southern California. As of spring 2006 there were over 30 juvenile bald eagles on the northern Channel Islands, the result of annual reintroductions in summer 2002 - 2004. Moreover, 2 eagle pairs attempted to nest on Santa Cruz Island in 2006, and a bald eagle chick was hatched in an island nest for the first time since the 1950's.

The goal of the study is to release up to 12 juvenile bald eagles annually on the northern Channel Islands for 5 years, and to monitor released eagles and their prey for contaminant levels to determine if levels are sufficiently low to allow breeding. From 2002 to 2005 a total of 46 young bald eagles were released to the wild from hack towers on Santa Cruz Island. Because bald eagles mature at 4-5 years of age, birds from the first (2002) release group may begin breeding in 2006 or 2007. In addition to the 30+ eagles from the Santa Cruz reintroduction effort, several bald eagles reintroduced on Santa Catalina Island have taken up residence on Santa Cruz Island.

In spring 2006 2 pairs of bald eagles attempted to breed on Santa Cruz Island. One pair, comprising a 5-yr old male and 4-yr old female, both of Santa Catalina Island origin, laid an egg in an island nest in early March and hatched a chick in mid-April. A second pair comprised a 5-yr old male from Catalina and a 4-yr old female form Santa Cruz. The latter pair laid at least 1 egg in late March or early April.

Bald eagles from all release years have been recorded on Santa Rosa Island during late fall and winter. Released bald eagles have been observed feeding on carcasses and gut piles from the commercial hunt and annual cull of mule deer and elk on that island. Eagles feeding on Santa Rosa ungulate carcasses are exposed to lead bullet fragments in the carcasses. In 2006, an injured and disoriented bald eagle was captured by hand on Santa Rosa Island (Garcelon 2006). A test of the bird's blood indicated a lead concentration of 0.522 ppm, a level classified as sub-clinical lead exposure. Subsequent treatment of the eagle with calcium EDTA successfully reduced the blood lead concentration.

The long-term success of eagle reintroduction efforts on the northern Channel Islands depends on contaminant levels in eagles and their prey, and attendant effects upon eagle reproduction. In 2006, baseline and recapture blood samples for released eagles will be tested for DDT and PCB, as will samples from eagle prey items (marine fishes, seabirds, and pinniped carcasses).

Table 19. Expenditures by NPS, according to funding source, for island fox recovery actions in fiscal year 2005 (October 1, 2004 through September 30, 2005).

	Park Base 8120-3000-NZI	NRPP 8120-0525-NNE	Fox Donation 8120-7150-600	NPF Settlement 8120-7175-600	Hoegh Settlement 8120-8504-600	Fox Base 8125-1000-NZE	Total
Progr. Coord.	92,890						92,890
Ann. Meeting				11,629		2,661	14,290
Eagle Remov.		146,000		18,850			164,850
Fox Food		3,260		2,198		14,035	19,493
Pen Enhance.		10,152		-4,624		6,035	11,562
Personnel		76,054		5,057	20,107	344,368	445,586
Prey Analysis				7,808		10,503	18,311
Supplies		7,585	7,495	12,112	7,679	28,923	63,794
Transportation				31,235		27,537	58,772
Travel		6,429		10,401		10,726	27,556
Vet Costs		1,520		12,757	55	10,344	24,676
Total	92,890	251,000	7,495	107,423	27,841	455,130	941,780

Budget

A total of approximately $941,780 was spent by the NPS on island fox recovery on the northern Channel Islands in fiscal year 2005 (Table 22), and a variety of funding sources contributed to the effort. Monies from the new base increase for fox recovery comprised the largest single NPS funding source, at $455,130.

Captive breeding costs totaled approximately $651,440, and included the full costs of island fox care on San Miguel and Santa Rosa Islands, as well as the costs of food and vet care on Santa Cruz Island. The remainder of the costs for captive breeding on Santa Cruz Island were borne by the Nature Conservancy, which also funded the remainder of golden eagle removal in 2005 and the costs of radiotelemetry monitoring of wild Santa Cruz Island foxes. From July 2005 – June 2006, TNC spent over $250,000 on captive breeding and wild fox monitoring, and approximately $200,000 on golden eagle removal (S. Morrison, TNC, pers. comm.).

In 2005 the NPS continued its support of the annual fox recovery team meeting, expanded breeding pens at the captive facilities on Santa Rosa and San Miguel, and funded a study of prey remains in golden eagle nests.

Future Costs

Estimated costs to NPS for island fox recovery actions in fiscal year 2006 total over $800,000 (Table 23). Personnel costs for captive breeding, reintroduction and monitoring comprise the single largest expenditure, at over $400,000. The estimated cost of $80,000 for golden eagle removal represents approximately half of the 2006 effort, the remainder of which will be funded by TNC.

Available funding sources include the parkbase increase for island fox recovery ($477,000), settlement monies from environmental contaminant cases, and combined funding from the NPS Natural Resource Preservation Program and Regional Natural resource program for fecal genotyping.

Table 20. Anticipated cost to NPS of island fox recovery actions in fiscal year 2006.

Category	Cost
Program coordinator	98,368
Personnel	406,133
Travel	21,964
Eagle removal	80,000
Fox food	36,000
Fecal genotyping study	50,430
Transportation (flights)	50,000
Supplies	30,000
Veterinary care	30,000
Fox meeting	18,000
Total	820,895

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Appendix A Standard Operating Procedure for Island Fox Husbandry

STANDARD OPERATING PROCEDURE

Animal Care Protocol for Captive Island Foxes Held at Channel Islands National Park Facilities

October 2005

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PURPOSE: To ensure meeting of animal welfare standards and proper care of island foxes held in captivity and to provide a captive environment that produces animals suitable for reintroduction into their former range.

INTRODUCTION:

Holding facilities:

There are currently six separate captive breeding facilities for island foxes on San Miguel, Santa Rosa, and Santa Cruz Islands. Pens are constructed of 11½-gauge fence mesh with 1 3/8″ openings secured to 1 5/8″ or 1 3/8″ tubular frames to form 10′ X 10′ and 6′ X 10′ pen components. Components are fastened together using saddle-clamps. Pens are fully enclosed with wire mesh roofs and hardware cloth ground skirts to prevent foxes from tunneling out. Pens are equipped with exterior ground skirts to prevent island spotted skunks, and released wild foxes, from tunneling in. The majority of pens also have a 10′X 10′ section that can be closed off with a gate to assist in captures, and when necessary to isolate individual foxes within a pen. A combination of electric and/or wire exclosure fences have been constructed around 5 of the 6 captive facilities to prevent aggression between wild and captive foxes.

On San Miguel Island, there are two captive breeding facilities – Brooks and Willow Canyons. The Brooks Canyon facility consists of eleven pens, each 500 sq. ft., separated by topography into three sub-sites. Pen shape consists of U, L, and Z shape footprints. All pens are equipped with electric fences (one rope, four inches from the ground and pen) as deterrents for captive / wild fox interactions. The Brooks Canyon site pens are clustered as groups of 3-3-5 east to west with 100-1000 foot

spacing between clusters. The Willow Canyon facility consists of eleven pens (one 800 sq. ft and eight 600 sq. ft. breeding pens and two 200 sq. ft. holding pens), all rectangular shaped. The facility is protected by a six foot wire mesh fence with overhang and ground skirt. Distances between pens on San Miguel range from 6-10 feet at the Willow Canyon site (pens M1-M11) to 30-70 feet apart at the Brooks Canyon site (pens M12-M22).

On Santa Rosa Island, there are two captive breeding facilities – Caballo Muerto and Windmill Canyon. The Caballo Muerto facility (pens R13-R20 and R23) consists of ten pens (seven 500 sq. ft. breeding pens and three 200 sq. ft. holding pens). Pen shape consists of L and Z shape footprints. The main facility is protected by an eight foot wire mesh fence with groundskirt and a three-rope earth (fence) ground return electric fence system overlapping the top of the wire mesh fence. One solitary pen (R13) is protected by an eight foot wire mesh fence with groundskirt and overhang. The Windmill Canyon facility (pens Q1-Q2, R1-R12, and R21-R23) consists of nineteen pens (one 800 sq. ft., five 700 sq. ft, and eight 600 sq. ft. breeding pens and three 300 sq. ft and two 200 sq. ft. holding pens). Pen shape consists of rectangular, L, P, and Z shape footprints. Distance between pens range from 20 to 100 feet apart.

On Santa Cruz Island, there are two captive breeding facilities – Navy and Valley sites. The Navy site (pens Q and C1-C10) consists of eleven pens (ten breeding pens, one holding pen). The pens vary in distance from 30 feet to 300 feet as the facility is spread along a ridge. The Valley site (pens C11-C24) consists of fourteen pens (ten breeding pens, two holding pens). An electric / wire mesh perimeter fence surrounds the Valley site facility.

For San Miguel and Santa Rosa Islands, pen interiors have combinations of above and below ground wooden and rock shelters, as well as climbing structures, underground tubes, and elevated resting platforms. Additional pen furniture is always under development and variation within the pen environment is encouraged. Required breeding pen enhancements include double shelves surrounded by shadecloth. Pyramid wind shelters are to be placed in most pens (especially at windy sites). Also, a minimum of three den boxes are to be placed within each breeding pair pen. Two new wooden den boxes, one small (18″ by 18″) and one large (24″ by 30″, with an interior divider), are to be placed within all breeding pens during fall 2005. A small non-wood material den box is also slated for placement within breeding pair pens. Extensive shadecloth is attached to pens to provide protection from sun, rain, and wind; and also provides a visual barrier between pens. Wherever possible native vegetation

is left or planted in and around pens, for added enhancement and security.

HUSBANDRY

A. Feeding and water:

Foxes are fed once daily, at dusk to coincide with their normal biorhythms. Each pen has two sets of bowls which are traded out at the evening feeding. Pair pens have either one or two bowls depending upon intra-pair behavior and/or presence of pups. Scattering is another technique used for pairs with suspected intra-pair behavior difficulties (e.g. food competition aggression). If available, kibble dispensing toys should be partially filled and used two to four times a week.

Foxes are fed Science Diet (Hills Pet Products, Topeka, KS), a high-grade dry dog food (protein 21.5%, fat 13.0%) once daily, supplemented by a variety of nuts, seeds, fruits, and vegetables and hard-boiled eggs. Foxes receive dead or live mice, or dead coturnix quail 1-2 times per week on average, with natural food items fed more often during the pup weaning stage. Foxes are not given moist meat-based food, such as canned cat or dog food, or fruits high in citric acid since that may result in gingivitis and tooth loss. When possible other natural food items such as insects and native vegetation are fed.

The amount of food given daily is equal to around 3%, dry weight, of the island fox body weight (i.e., 2.3 kg - 2.8 kg adult gets a ½ cup base kibble diet plus supplements). Diets are further corrected after weighings to compensate for foxes with higher or lower metabolisms. Captive fox weights average higher then wild fox weights (male-2.24 kg, female-2.07 kg). Foxes slated for release should weigh slightly more than the average wild weights, allowing a reserve of body stores for the initial reintroduction period, and be fed more live prey to improve their hunting skills. However, foxes heavier then 2.8 kg should not be released until their weights are reduced to prevent an initial high percentage weight loss in the first few weeks of release.

Science Diet Growth Formula is introduced into the diets of foxes paired for breeding beginning in March. The normal adult kibble is replaced in 1/8 cup weekly increments until ½ of the normal diet is growth formula by early April. This allows the adults to get accustomed to the new kibble and provides extra nutrition for pregnant and/or lactating females. When pups are confirmed, additional growth formula is increased in 1/8 – 1/4 cup increments until leftovers are present or until all foxes (pups

and adults) are receiving a full complement of kibble. Pregnant and lactating females also receive priority for available natural supplements. Starting in late summer, as pups approach adult size, they are weaned off the growth formula and onto the adult formula at standard amounts.

Other diets used for sick or injured animals include Science Diets K/D (for kidney disease), I/D (for gastro-intestinal disorders), and A/D (for aiding in recovery from illness, injury, or surgery) formulas.

Foxes are provided with water *ad libitum*. A minimum of one three-quart water bowl is provided to all pair pens and one one-quart bowl for individual fox pens, additional capacity is added when needed. Water is transported from the mainland for San Miguel foxes because of water quality and availability issues on that island, though on Santa Rosa and Santa Cruz Islands island water is utilized. For sick or injured foxes that are dehydrated, fluids are administered subcutaneously in 60-120 mL amounts on recommendation a project veterinarian.

B. SANITATION

Each island facility is treated as a separate unit and care is taken to minimize potential transfer of pathogens between them. Separate outer-clothing including shoe covers are located on each island, and are used in the event of a suspected disease outbreak. Daily precautions include caretaker’s bleaching of shoes or rubber boots before entering each pen, each and every time, and keeping items from each facility separate. Caretakers are also instructed to avoid bringing out any items to the island that have come into contact with domestic pets. Human intrusion is kept to a minimum by feeding and watering just inside each pen gate. Fox scat is removed from each pen every other day. During the breeding season, care is taken to reduce time and disturbance within the pens, especially if breeding pairs show elevated levels of stress during pen entry. Non-consumed food items are removed from the pens every day and disposed of in trash receptacles.

For sanitation purposes, it is best not to transfer fox toys from one pen to another. Kibble dispensing toys should be emptied out after each use, sprayed with a sanitizing solution, and left outside the pens to air-dry before reusing. Once a toy is retired from a pen, it requires a thorough cleaning and sterilization (bleach and water solution) before being sent to a different pen. All toys require sterilization before being placed in a pen.

Each pen has an individual food bowl washed out daily with soap and hot water and then bleached. Disposable food handler's gloves should be worn during food preparation to minimize human contact with the food bowls.

When preparing multiple facility food bowls, food for one facility is prepared at a time and then placed in secure airtight containers, surfaces are then disinfected before the second facility's food bowls are prepared.

On San Miguel Island, fox feces are currently cleared from pens every other day and piled in locations 10-20 meters away from the pen. On Santa Rosa Island, enzyme-activated, below-ground disposal systems have been added for long term feces disposal. The goal is to quickly break down the waste and minimize exposure of foxes and other island fauna to potential parasite infections.

Pen maintenance is a year-round job with continuing replacement of shade cloth, removal of invasive weeds, re-covering of ground skirt, rebuilding structures, trail maintenance, and monitoring pen security and integrity. Caretakers should always be working on one of these projects. During breeding, whelping, and early post-whelping seasons, February 1st to May 1st, when foxes are more sensitive to disturbance due to breeding activities, all pen maintenance is suspended unless absolutely necessary (i.e. foxes are imperiled). Once a year, all saddle-clamps that link pen panels should be checked for tightness.

C. Periodic observations:

Animals are observed during feeding, and behavior is recorded. The minimum required number of observations for each adult fox is twice per week, including one observation or location indicative of mobility (in order to access fox health). During the whelping season, disturbance must be kept to a minimum. It is crucial that caretakers become familiar with individual animals' behavior to notice any significant changes that may indicate a problem. Because these are remote facilities and lack adequate power sources, some video and audio monitoring may occur; but the extent will be limited.

D. Breeding, Whelping, and Weaning

Although minimizing contact between the care-taking fox technicians and foxes is a year-round goal, between the months of February and June extra steps are taken to minimize human presence and disturbance at the facilities. All feeding and watering is done on the near side of the pens (area closest to entry gate). Routine pen and facility maintenance is curtailed

unless absolutely necessary. Scat removal is performed less intrusively, den box lids are not scraped, and scat is only removed on the near side during the early whelping phase. In addition, pups are not handled (or searched out) until they are active outside of the den, usually in June, and only if necessary. Adult foxes should only be caught during this time if absolutely necessary (serious injury, illness, aggressive male behavior towards newborn pups) and after consultation with a project veterinarian.

E. Pen Captures

Island foxes are captured within the pens using Tomahawk capture nets (Tomahawk Live Trap, Tomahawk, WI) or a Tomahawk wire mesh traps. Capture by hand, while a fox is in a den or other structure, is another method utilized. Each method has associated risks to both fox and handler. Netting is the quickest method of capture and gives the handler almost immediate control of the animal; however, this method should be attempted by trained, experienced personnel only. Traps are most often associated with teeth damage, nets with torn nails. Traps are not appropriate for small pups as the door could cause serious injury when closing. Pups can often be caught by gloved hand within dens or shelter boxes. The basic philosophy for captures is that short duration high stress is preferred to a long drawn out capture. If an animal is not caught quickly, handler must exit the pen and wait for the animals and the handlers to calm down.

The biggest risk in captures, after the initial restraint of the animal, is hyperthermia due to physical exhaustion and stress, and to a lesser degree, hypothermia when using chemical restraint. Temperatures should be checked immediately after capture if the animal is going through a work-up or after a prolonged capture process. Temperatures of 101-102° F are normal; temperatures at 103-104° F require initial cooling procedures (alcohol applied to pads and pinnas). Temperatures above 104° F require additional cooling (alcohol applied to pads, pinnas, and ventral side and resting the fox on ice packs). Any temperatures above 105° F require all procedures to stop until the animal’s temperature stabilizes (extensive alcohol application to body, water immersion). If the animal has a temperature in the mid to low 90s°, then warm towels, heating packs, or a heating pad can be used to externally warm the animal. A sedated animal may require a heating pad and cannot be left unattended; towels can be warmed in a microwave or oven, but should be checked to make sure they are not too hot before being applied to foxes.

Guidelines established by the American Society of Mammalogists (1998) will be followed in all capture and handling of animals.

F. Facility site visits:

No site visits are allowed at the island facilities without caretaker or project personnel escort. No site visits other then normal caretaking duties and personnel are allowed between February 1st and April 30th. Since the captive facilities are not zoological parks, and all the foxes are ultimately slated for release into the wild, members of the public (island visitors, campers, and other persons) should never be brought to or shown the pen sites. Patients in the "foxpitals" (island veterinary facilities) should not be viewed or handled by members of the public or other persons not performing assessment, treatment, or other care. Only veterinarians, fox program personnel and other park personnel assisting the fox crew may view and handle these patients.

G. Health Care:

Animals undergo annual veterinary examination and receive veterinarian care as needed. Fox technicians perform minor veterinary procedures under guidance of a project veterinarian. Project veterinarians treat animals that are seriously sick or injured. Any observed animal that appears to be injured or sick will be captured and examined (immediacy depends upon severity). If the examined fox requires medical attention, then the project veterinarian will be contacted for required treatments.

New animals (wild caught or recaptured from the field) are housed separately for two to four weeks before being introduced to potential mates, or brought into proximity of other captive foxes.

Several parasites are currently present within the captive populations. Two of these parasites (*Angiocaulus* and *Spirocera*) have not been found previously in the *Urocyon* species and foxes are currently not treated for these parasites due to potential risks of treatment. As such, the current decision is not to treat an animal carrying these novel parasites due to potential risks. This issue is continually under discussion and treatment for some internal parasites in some animals may be necessary on a case by case basis. On Santa Cruz and Santa Rosa Islands, foxes are treated for ectoparasites with either Frontline TopSpot or Advantage during vet work-ups and on an as needed basis when animals are in hand.

All captive foxes are vaccinated against canine distemper (Merial, Inc., Duluth, GA) and rabies. No other vaccines are considered safe and effective for island foxes at this time.

H. Catastrophic Events:

Fire-

All breeding facility locations are marked as priority locations for air tanker and helicopter drops, and fuels reduction occurs around the pens. At this time, only one fox caretaker on Santa Rosa Island is qualified to respond to wildland fires. Therefore, if there is a fire in the vicinity of a captive facility, most staff are not to go into the danger area without proper PPE, and then only if accompanied by a qualified fire fighter. If there is time, then all efforts should be made to capture and transport foxes, in sky kennels or Vari-kennels, out of the fire area. If less time is available, and there is a good chance that the fire will reach the facility, pens and perimeter fence gates should be opened and foxes chased away from the direction of the fire. **Under no circumstances should fox techs try to out-race a fire approaching a facility, or in any way put themselves in danger to save foxes.**

Flood-

To date all facility locations appear adequate in regard to flooding. In El Nino years, there is potential for a 100-500 year flood event that could threaten the Windmill or Willow sites. In the event of such an occurrence, foxes should be captured and transported to higher ground. This has to be done before the water rises, so on-island personnel must make the call on the level of the threat. Please seek the advice of other on-island/Park personnel (e.g. island rangers, maintenance), if faced with making such a decision. Foxes can be held in kennels for a couple of days, so always make the conservative call if flooding is a potential threat. At Santa Rosa Island's Windmill Canyon captive facility, there is also the potential for mud and rock slides to affect pens in years with higher rainfall amounts.

Disease-

Disease posses the greatest threat to any captive population. At this time, our facilities follow a daily caretaking protocol that minimizes the risks of disease transfer but does not eliminate it. In the event of a disease outbreak, the initial response is to isolate the animal or pen from the rest of the captive population and increase the level of quarantine procedures. Blood and fecal samples should be taken from the sick fox for immediate shipment to the mainland for analysis. No exposed

clothing worn in the infected animals pen/pens should come in contact with any other pen (Tyvex suits and shoe covers must be used). In such an event, no clothing or equipment worn to one facility is to be worn to the second facility. Caretakers must shower after leaving the facility where the infected animal(s) are present and before going to the other facility where the infection is not present. All bowls and any other item from the infected pen should not be brought into contact with other pens or common areas (wash and bleach the bowls in a bucket). It is better to lose one animal or facility than the whole population, so don't let the desire to comfort a sick animal interfere with the potential risk.

REFERENCES:

American Society of Mammalogists. 1998. Guidelines for the capture, handling and care of mammals as approved by the American Society of Mammalogists.. J. Mammal. 79:1416-1431.

Appendix B Foxes Currently in Captivity and the Wild

Table 21. Island foxes currently in captivity on San Miguel Island.

Pen	PitTag	Studbook Number	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
M01	87F53	133	M	4	Captive	7574A	92C32		
	85764	135	F	4	Captive	44829	90D1A		
M02	E4B2D	237	M	2	Captive	47B06	E2677		
	C5D00	231	F	2	Captive	44829	90D1A		
M03	7574A	32	M	8	Wild			5/14/1999	Willow Canyon
	92C32	31	F	8	Wild			5/17/1999	Willow Canyon
M04	11F73	79	M	5	Captive	44829	90D1A		
	F6558	49	F	7	Wild			10/4/1999	Green Mountain
M07	94714	268	M	1	Captive	47B06	E2677		
M08	7534A	14	F	13	Wild			9/4/1999	Nidever Canyon
	92804	12	F	14	Wild			10/24/1999	Willow Canyon
M09	C311C	165	M	3	Captive	11F73	F6558		
	2033F	270	F	1	Captive	E666D	B0B25		
M10	57150	35	M	8	Wild			10/4/1999	Green Mountain
	3167E	271	F	1	Captive	E666D	B0B25		
M11	47B06	63	M	6	Captive	44829	90D1A		
	E2677	36	F	8	Wild			9/11/1999	Willow Canyon
M18	C4A16	82	M	5	Captive	7574A	92C32		
	71071	46	F	7	Wild			8/23/1999	Cardwell
M19	07541	266	M	1	Captive	7574A	92C32		
	11929	62	F	6	Captive	44829	90D1A		
M20	52249	227	F	2	Captive	C4A16	71071		
M21	85D02	47	M	7	Wild			9/17/1999	Cardwell
	90C7D	168	F	3	Captive	C4A16	71071		
M22	E666D	167	M	3	Captive	C4A16	71071		
	B0B25	48	F	7	Wild			9/28/1999	Nidever Canyon

Table 22. Island foxes currently in the wild on San Miguel Island.

PitTag	Other	Studbook Number	Sex	Born	Age	Released or Radiotagged
83C24	M201	81	M	Captive	5	10/28/2004
E770A	F301	233	F	Captive	2	10/28/2004
B4E60	M203	136	M	Captive	4	10/29/2004
E270B	M202	137	M	Captive	4	10/29/2004
D7074	F302	234	F	Captive	2	10/30/2004
70C1D	M204	80	M	Captive	5	10/30/2004
23B15	F303	236	F	Captive	2	11/6/2004
D1531	M205	232	M	Captive	2	11/6/2004
06E4A	F304	235	F	Captive	2	11/7/2004
84E33	M206	161	M	Captive	3	11/7/2004
91167*		158	M	Captive	3	6/15/2005
03A13	F305	162	F	Captive	3	7/30/2005
53A78	F306	163	F	Captive	3	9/30/2005
5797C	M207	159	M	Captive	3	9/30/2005
50572	M208	267	M	Captive	1	10/14/2005
F4C46	M210	274	M	Captive	1	10/19/2005
B282A	F307	275	F	Captive	1	10/19/2005
63E0F	M211	226	M	Captive	2	10/20/2005
15A49	F309	269	F	Captive	1	10/22/2005
52F0C	M213	164	M	Captive	3	10/28/2005
C111F	M209	160	M	Captive	3	10/29/2005
25A63	F310		F	Wild	1	11/5/2005
53E39	F311		F	Wild	1	11/19/2005
66C6E	M214	139	M	Captive	4	11/23/2005
13212	M215	138	M	Captive	4	11/23/2005
B0E36	M212	134	M	Captive	4	11/27/2005
B7E0A	F308	140	F	Captive	4	11/27/2005
F3164	F313	228	F	Captive	2	12/1/2005
46629	M218		M	Wild	1	12/4/2005
87067	M217		M	Wild	1	12/4/2005
B3252	F316		F	Wild	1	12/4/2005
06125	F315		F	Wild	1	12/4/2005
22A35	M219		M	Wild	1	12/5/2005
44829	M216	33	M	Wild	8	12/5/2005
97036	F317	273	F	Captive	1	12/6/2005
93901	M221	229	M	Captive	2	12/6/2005
30D5F	F318	272	F	Captive	1	12/6/2005
C7303	M220	83	M	Captive	5	12/6/2005
0192F	M222		M	Wild	1	12/23/2005
B112A	M223		M	Wild	1	2/5/2006

*escaped from captivity June 2006; never recaptured

Table 23. Island foxes currently in captivity on Santa Rosa Island.

Pen	PitTag	Studbook Number	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
R01	80C3F	222	M	2	Captive	F0223	F4A18		
	25D54	149	F	4	Captive	73D0D	3512D		
R02	7235F	219	M	2	Captive	B067E	47304		
	A5E60	265	F	2	Wild	A045A	33131	10/19/2004	Windmill Canyon
R03	A180A	53	F	6	Wild			10/24/2000	Skunk Point
R04	64A43	304	M	1	Captive	B067E	47304		
	D590E	298	F	1	Captive	80C3F	25D54		
R05	F0223	28	M	8	Wild			4/6/2000	Smith Highway
	F4A18	42	F	7	Wild			3/29/2000	Smith Highway
R06	0507B	174	M	3	Captive	73D0D	3512D		
R07	70518	59	M	6	Captive	D3D76	A7015		
	10030	26	F	8	Wild			4/5/2000	Smith Highway
R08	2410E	54	F	6	Captive	B067E	1612C		
R09	32219	303	M	1	Captive	B067E	47304		
	E485E	299	F	1	Captive	80C3F	25D54		
R10	B067E	24	M	8	Wild			3/26/2000	Smith Highway
	47304	145	F	4	Captive	70518	10030		
R11	73D0D	44	M	7	Wild			7/24/2000	Torrey Pines
	3512D	29	F	8	Wild			11/5/2000	Skunk Point
R12	47E09	178	M	3	Captive	D3D76	1612C		
	A3B6D	223	F	2	Captive	F0223	F4A18		
R14	D187A	27	F	8	Wild			4/5/2000	Smith Highway
R15	96C2E	74	F	5	Captive	0654E	D187A		
R16	1271E	144	M	4	Captive	70518	10030		
R18	07061	225	F	8	Wild			5/14/2001	Windmill Canyon
R19	1612C	40	F	7	Wild			3/23/2000	Smith Highway
R20	C4F63	177	M	3	Captive	D3D76	1612C		
R21	97541	305	M	1	Captive	47E09	A3B6D		
	31049	218	F	2	Captive	70518	10030		
R22	B6255	302	M	1	Captive	B067E	47304		
	A7954	170	F	3	Captive	0654E	D187A		
R23A	85420	224	M	2	Captive	84F28	95B34		
R24	9230A	220	M	2	Captive	B067E	47304		
FXPTL	37E00	52	M	6	Wild			9/9/2000	Skunk Point

Table 24. Island foxes currently in the wild on Santa Rosa Island.

PitTag	Other	Studbook Number	Sex	Born	Age	Released or Radio-collared
A266D	F104	176	F	Captive	3	11/21/2003
33131	F106	43	F	Wild	7	1/17/2004
34614	F108	70	F	Captive	5	1/19/2004
14125	F107	179	F	Captive	3	1/19/2004
01460	F109	152	F	Captive	4	2/5/2004
37C61	F112	58	F	Captive	6	10/22/2004
F3950	F111	75	F	Captive	5	10/22/2004
B4B2B	M04	69	M	Captive	5	10/22/2004
7792E	M06	147	M	Captive	4	10/22/2004
03332	M09	216	M	Captive	2	10/30/2004
D4C78	M08	169	M	Captive	3	10/30/2004
D0F75	F118	264	F	Wild	2	12/11/2004
52E0D	F119	172	F	Captive	3	10/1/2005
13737	F121		F	Wild	1	10/7/2005
84F28	M11	55	M	Captive	6	10/13/2005
63F2A	F123	151	F	Captive	4	10/20/2005
F3D2F	M12	72	M	Captive	5	10/20/2005
E6D1E	F124	78	F	Captive	5	10/29/2005
B7A6D	M13	221	M	Captive	2	10/29/2005
7145F	M14		M	Wild	1	10/31/2005
26210	M15		M	Wild	1	11/4/2005
C7B1B	F125	175	F	Captive	3	11/13/2005
60B1D	F126	76	F	Captive	5	11/18/2005
95906	F103	143	F	Captive	4	11/20/2005
75125	M02	77	M	Captive	5	11/20/2005
0654E	M18	60	M	Captive	6	11/23/2005
83149	M19	300	M	Captive	1	11/25/2005
25C14	M10	301	M	Captive	1	11/26/2005
E7E64	F129		F	Wild	1	1/12/2006
B7F1A	M20		M	Wild	1	1/13/2006
3581A	*		F	Wild	1	
C5B32	*		F	Wild	1	

*captured as pups in summer 2005,
but weights too low to affix radio-collars

Table 25. Island foxes currently in captivity on Santa Cruz Island.

Pen	PitTag	Studbook Number	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
C01	A4628	85	M	9	Wild			3/11/2002	Islay Canyon
	30B2D	84	F	7	Wild			2/27/2002	Cebada Canyon
C02	A6D41	87	M	6	Wild			2/27/2002	Sauces Canyon
	D2C13	86	F	6	Wild			2/27/2002	Prisoner's Marsh
C03	A4F4C	263	M	2	Captive	1783E	87035		
	0786F	88	F	8	Wild			3/2/2002	China Pines
C04	B506A	240	M	6	Wild			1/15/2003	Isthmus
	71B0E	241	F	6	Wild			1/15/2003	Isthmus
C05	36172	91	M	7	Wild			2/27/2002	Pelican Bay Trail
	72901	90	F	6	Wild			2/27/2002	Prisoner's Canyon
C06	86B1A	93	M	6	Wild			2/27/2002	Pozo Canyon
	86F17	92	F	6	Wild			3/10/2002	Pozo
C07	45411	95	M	6	Wild			3/1/2002	China Pines
	D2210	94	F	5	Wild			3/11/2002	Cebada Canyon
C08	96A5A	256	M	2	Captive	36172	72901		
	44D52	243	F	3	Captive	45411	D2210		
C09	1783E	213	M	9	Wild			12/4/2002	Coches Prietos
	87035	212	F	8	Wild			12/4/2002	Coches Prietos
C10	C480E	260	M	2	Captive	86B1A	86F17		
	D3035	244	F	3	Captive	45411	D2210		
C13	B0C69	257	M	2	Captive	36172	72901		
	B365F	254	F	2	Captive	F3F0E	16C30		
C14	9282E	247	M	2	Captive	A6D41	D2C13		
	C3262	259	F	2	Captive	86B1A	86F17		
C15	24063	253	M	2	Captive	F3F0E	16C30		
	6517A	246	F	2	Captive	A4628	30B2D		
C16	D575E	248	F	2	Captive	A6D41	D2C13		
C17	C3E7E	180	M	3	Captive	A4628	30B2D		
	1784B	252	F	2	Captive	F3F0E	16C30		
C18	1415A	89	M	6	Wild			3/3/2002	China Pines
	F7C1D	262	F	2	Captive	45411	D2210		
C19	4112D	296	M	1	Captive	36172	72901		
	10E01	245	F	2	Captive	A4628	30B2D		

Pen	PitTag	Studbook Number	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
C20	55D2C	295	M	1	Captive	02361	E250C		
	01C77	181	F	3	Captive	A4628	30B2D		
C21	87A65	250	M	2	Captive	B506A	71B0E		
	03042	261	F	2	Captive	45411	D2210		
C22	F3F0E	182	M	3	Captive	A6D41	D2C13		
	16C30	242	F	5	Wild			6/6/2002	Isthmus Pen Site
C23	02361	183	M	3	Captive	A6D41	D2C13		
	E250C	185	F	3	Captive	86B1A	86F17		
C24	61902	286	M	1	Captive	B506A	71B0E		
	F7727	255	F	2	Captive	36172	72901		
C25	6360F	308	M	1	Captive	1783E	87035		
	24F10	310	F	1	Captive	F7C1D	1415A		
C26	1277C	292	M	1	Captive	45411	D2210		
	06C60	294	F	1	Captive	C3E7E	1784B		
C27	80810	283	M	1	Captive	A6D41	D2C13		
	83B3F	258	F	2	Captive	86B1A	86F17		
C28	A2128	291	M	1	Captive	45411	D2210		
	F0E3A	282	F	1	Captive	A4628	30B2D		
C29	87276	290	M	1	Captive	86B1A	86F17		
	85A5C	293	F	1	Captive	45411	D2210		
C30	84F7E	307	M	1	Captive	1783E	87035		
	61E2E	287	F	1	Captive	B506A	71B0E		
C31	57263	309	M	1	Captive	1783E	87035		
	5775A	297	F	1	Captive	36172	72901		
C32	B675D	288	F	1	Captive	86B1A	86F17		
	0420A	285	M	1	Captive	A6D41	D2C13		
C33	D010A	284	M	1	Captive	A6D41	D2C13		
	27222	289	F	1	Captive	86B1A	86F17		

Appendix C Injuries and Other Health Problems in Captive Island Foxes, 2005

Table 26. Injuries and other health problems in captive San Miguel Island foxes, 2005.

Date	ID	Sex	Pen	Injury	Treatment
1/13/05	7534A	F	M09	Bite wound, torn tendon, necrotized	Wound sutured, antibiotics; released into pen on 1/29/2005
1/13/05	44829	M	M07	Nail injury	Topical treatment, released to pen
1/19/05	03A13	F	M22	Minor pad wound	No treatment, released to pen
1/19/05	91167	M	M22	Minor nail wound from capture	Topical treatment, released to pen
1/26/05	66C6E	M	M19	Pad wound	Suture and drain, antibiotics; released into pen on 3/09/2005
1/28/05	57150	M	M14	Pad wound	Suture, antibiotics; released into pen on 2/07/2005
1/30/05	B0B25	F	M12	Ear injury	Antibiotics; released into pen
2/7/05	92804	F	M19	Cut on forepaw, likely from fighting through pen wall, because mate (66C6E) was in foxpital at the time	Wound glued, antibiotics; released back into pen on 3/11/2005
2/12/05	7534A	F	M09	Saw blood on neck from minor bite marks; black line (scar?) On rt. hindleg	Closer monitoring
2/13/05	C5D00	F	M04	Minor bite marks on head and ears	None
3/1/05	92C32	F	M03	Minor abrasions on muzzle and puffy left eye area	Closer monitoring
4/28/05	52249	F	M02	Severe head and neck injury from mate aggression	Closer monitoring for 4 days, wound sutured, antibiotics; released into pen after male removed on 5/29/05
5/2/05	52F0C	M	M02	Minor trauma to eye	Antibiotics; released to pen
5/7/05	7534A	F	M09	Severe wound to hind leg with major muscle necrotization and maggots, mate aggression	Surgery performed and wound sutured, stapled, and drained, antibiotics; released to single fox pen on 6/18/05
5/22/05	92804	F	M19	Ear injury	Antibiotics; released to pen M2 on 6/17/05
7/18/05	13212	M	M21	Head wound, pen mate aggression	Surgery, sutures, antibiotics; released to pen M22 on 8/2/05
7/18/05	E4B2D	M	M21	Minor head wound, possible	Topical treatment,

Date	ID	Sex	Pen	Injury	Treatment
				from digging under groundskirting or pen mate aggression	biopsy, antibiotics; released to pen
8/1/05	C5D00	F	M09	Minor bite wounds on ears, mate aggression	Topical treatment; released to pen
8/1/05	93901	M	M09	Missing toenail	Topical treatment; released to pen
8/6/05	92804	F	M02	Ear infection, hematoma, perforated tympanic membrane	Antibiotics, cleaning, 2 grass awns removed from middle ear; in foxpital for 67 days. Oral antihistamine while in captivity. Release delayed until ear drum regrown.
8/15/05	C111F	M	M20	Minor toenail injury	Topical treatment, released to pen
10/14/05	C111F	M	M20	Split pad, torn nail	Daily cleaning with Chlorhexaderm, oral antibiotic. Release delayed until 10/29/05.
10/21/05	B0E36	M	M15	Lacerated toe left front paw, swollen	Daily cleaning with Chlorhexaderm, oral antibiotic. Release delayed until 11/22/05.
10/25/05	B0B25 + 1 pup	F	M12	Minor ear wounds, pen mate aggression	No treatment
10/28/05	F3164	F	M10	Bite wound on back of neck, mate aggression	Clean with Chlorhexaderm, topical application of Neosporin, oral antibiotic. Lancing of lump determined to be scar tissue. Release delayed until 11/22/05.
11/02/05	90C7D	F	M16	Laceration on right hind leg, some minor wounds on ears, possible mate aggression	Clean with Chlorhexaderm, topical application of Neosporin, oral antibiotic
11/11/05	E2677	F	M11	Minor toe nail wound	Topical treatment, release to pen
11/16/05	11929	F	M17	Laceration on muzzle with wounds going all the way through lip, some bruising and wounds to gum from teeth, possible mate aggression, 2 pups still in pen	Clean with Chlorhexaderm, Surgery performed on 11/18/05, sutures, oral antibiotics.

Table 27. Injuries and other health problems in captive Santa Rosa Island foxes, 2005.

Date	Fox ID	Sex	Pen	Injury	Treatment
1/21/05	85420	M	R20	Tear to outer margin of right ear; possible scab removal during capture for vaccination	Topical treatment; released to pen; closer monitoring
1/22/05	80C3F	M	R01	Nail injury during capture	Topical treatment; released to pen
2/4/05	95906	F	R08	Hair loss and kink in tail, sensitive to touch, bloody anal area due to tick bites, high temp	Brought to foxpital and consulted vet. No open wounds found so cleaned tick scabs topically and released back into pen same day
2/13/05	52E0D	F	R23B	Small cut between digits	Closer monitoring (treatment postponed due to wild prolapse); topically treated released to pen (see 2/20/05)
2/14/05	51E3E (M5)	M	Wild	Prolapsed rectum	Surgery, antibiotics; released to wild 2/25/05
2/20/05	52E0D	F	R02	Bite on muzzle from failed mate introduction	Antibiotics; released to new pen on 2/27/05
5/17/05	2410E	F	R03	Mate aggression to tail	Topical treatment, antibiotics in food; released to different pen
5/18/05	10030	F	R07	Mastitis	Antibiotics in food; released to pen
5/18/05	95906	F	R08	Hind leg and ear injuries due to mate aggression	Staples, fluids, antibiotics; released to new pen on 5/28/05
5/18/05	75125	M	R08	Minor ear injuries	Topical treatment; released to pen
5/18/05	962CE	F	R13	Mastitis, uterine infection	Antibiotics in food; released to pen
5/18/05	E3F0F	F	R16	Mastitis	Antibiotics in food; released to pen
5/18/05	A5E60	F	R17	Mild mastitis	Antibiotics in food; released to pen
6/26/05	25D54	F	R01	Old wound on right front paw reinjured while escaping	Closer monitoring; no treatment needed
7/8/05	D187A	F	R	3rd digit right front paw injury	Antibiotics; released to new pen on 7/20/05
7/9/05	A5E60	F	R17	Neck/back wounds due to mate aggression	Antibiotics; released to new pen on 7/20/05
7/25/05	A180A	F	R20	Ear infection	Topical antibiotics, removal of grass awn; released to pen 8/20/05
8/16/05	A7954	F	R09	Eye irritation	Topical antibiotics; released to new pen on 8/23/05
8/21/05	B7A6D	M	R14	Bite wound to lower lip	none
8/21/05	E6D1E	F	R14	Bite wounds to rt ear and top	Topical treatment,

Date	Fox ID	Sex	Pen	Injury	Treatment
				of head	antibiotics in food; released to new pen
8/23/05	84F28	M	R09	Bite wounds to ear	Topical treatment, antibiotics in food; released to new pen on
8/23/05	60B1D	F	R04	Old bite wounds to both ears found at vet exams	Topical treatment, antibiotics in food, released to pen
8/24/05	53723	M	R04	Bite wounds to rt hind foot	Staples, antibiotics in food; released to pen
8/23/05	F3D2F	M	R06	Old bite wounds to right pinna found at vet exams	Topical treatment, antibiotics in food, released to pen
8/25/05	63F2A	F	R06	Bite wounds to foot	3 sutures, antibiotics in food; released to pen
09/07/05	E6D1E	F	R24Y	Laceration on toe	Staples, cefadroxil orally, clean with Chlorhexaderm, topical antibiotic, light bandage. Returned to pen 9/28, released 10/29.
09/22/05	1271E	M	R15	Eye swollen, infection	Topical application of antibiotic ointment 3x a day for 1 week. 7 days in foxpital.
10/07/05	37E00	M	R02	Dry eye syndrome, or KCS (Keratoconjunctivitis Sicca Condition). Tear ducts not working; fox is going blind	Rinse both eyes with saline 2 X day; apply ophthalmic ointment to both eyes 2 X a day. Longterm: remove fox from breeding program, send to mainland for daily treatment (February 2006)
11/05/05	A180A	F	R20	Burst abscess on neck	0.5 cc Clavamox 2X daily, rinse wound with dilute Chlorhexaderm
11/07/05	83149	M	R01	Minor wounds to left ear, top of head, and base of right ear	Topical treatment, moved to new pen by himself, released on
11/07/05	E485E	F	R01	Minor wounds to left hind foot and toe and right outer pinna	Topical treatment, released to pen
11/07/05	D590E	F	R01	Minor puncture wound to right medial foot	Topical treatment, released to pen
11/07/05	80C3F	M	R01	Old wounds to right hind foot	No treatment
11/07/05	25D54	F	R01	Old wounds to head and ears	No treatment
11/08/05	60B1D	F	R04	Puncture wound on back right paw	Antibiotic ointment applied topically; one tab Baytril daily for a week; released to wild 11/15/05
11/11/05	B067E	M	R10	Bite wound on neck	1.0 cc Clavamox daily, rinse wound with dilute

Date	Fox ID	Sex	Pen	Injury	Treatment
					Chlorhexaderm 2X daily
12/11/05	37E00	M	R02	Ear wounds	Foxpital; 0.75 cc Clavamox 2X daily, plus Otomax for irritated ear canal
12/11/05	3512D	F	R11	Raspy breathing	Cefa drops