

**National Park Service  
Channel Islands National Park**

**ISLAND FOX RECOVERY PROGRAM  
SAN MIGUEL AND SANTA ROSA ISLANDS  
2006 ANNUAL REPORT**

**Technical Report 07-04**

**Timothy J. Coonan  
Mitchell Dennis**

**National Park Service  
Channel Islands National Park  
1901 Spinnaker Drive  
Ventura, CA 93001  
Voice: (805) 658-5776  
Fax: (805) 658-5798  
Email: [tim\\_coonan@nps.gov](mailto:tim_coonan@nps.gov)**

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*Male M205, San Miguel Island, a captive-born male that has sired 2 wild litters since release in 2004*

## Executive Summary

During 2006, the National Park Service continued its program of captive breeding and release of island foxes (*Urocyon littoralis*) on San Miguel and Santa Rosa Islands. Summary statistics for the wild and captive populations are provided in Table 1. Reproduction in captivity in spring 2006 was relatively poor: 6 pups were born on San Miguel, and 9 on Santa Rosa. Ultrasound examinations conducted as part of a reproductive study indicated a high rate of neonatal loss on Santa Rosa, whereas on San Miguel pregnancy rates were low; only 5 of 12 pairs on San Miguel became pregnant. On Santa Rosa, a total of 21 pups observed on ultrasound in 10 litters were lost prior to pup emergence from the den. The cause of reproductive failure is unknown. No foxes died in captivity in 2006. In the fall, 16 foxes were released from captivity on San Miguel, and 13 on Santa Rosa. One of the released Miguel foxes died, as did 6 of the Santa Rosa released foxes. At the end of the year there were 16 foxes in captivity on San Miguel and 28 on Santa Rosa. During 2006 one fox escaped from captivity on Santa Rosa, and another was transferred to the Santa Barbara Zoo because of a condition (keraticconjunctivitis sicca, or “dry-eye”) that required daily veterinary treatment.

In 2006 annual survival of released and wild-born foxes was high on San Miguel (84%) and lower on Santa Rosa (49%). A total of 20 island foxes died in the wild on Santa Rosa Island in 2006, compared to 6 on San Miguel. At least 5 of the Santa Rosa mortalities were due to golden eagle predation and occurred early in the year. Five of the Santa Rosa mortalities that occurred in the latter half of the year were characterized by emaciation and bacterial infections.

### Monitoring Survival and Wild Fox Populations

In summer 2006 we deployed remote cameras near likely den sites on San Miguel and Santa Rosa Islands to determine reproductive success of wild island foxes. Pups were observed in 12 of 13 territories on San Miguel, and 4 of 10 on Santa Rosa. A total of 25 pups were observed on San Miguel, and 13 on Santa Rosa.

We conducted trapping in fall 2006 to monitor the small wild populations on each island. On San Miguel we trapped foxes on 4 small (3 x 6 trap) grids, in order to estimate fox density, and on transects in order to replace radiocollars, gauge reproduction through capture of pups, vaccinate wild foxes, and check physical condition of foxes. A total of 72 individuals were trapped, 39 on grids and 39 on transects. The density estimates for the 4 grids, as calculated with program DENSITY, were 1.1, 3.3, 1.2, and 1.5 foxes/km<sup>2</sup>. Multiplying the average density (1.7 foxes/km<sup>2</sup>) by the island area (38.1 km<sup>2</sup>) yielded a population estimate of 65 foxes. At the time, prior to fall releases, there were 66 foxes known to be alive on San Miguel. Small grids appear to work well for estimating density.

A total of 32 wild-born pups were caught on San Miguel during fall trapping. Reproductive success was estimated as the number of pups (32) divided by the number of adult females known to be alive on the island in spring 2006 (15). The estimated reproductive success of 2.1 pups per female was high compared to values from the 1990s, and reproductive success was found to be inversely correlated with the islandwide population estimate.

A total of 38 individuals, including 14 wild-born pups, were captured on Santa Rosa during fall trapping. Reproductive success was 1.4 pups/female (14 pups/10 females).

For the San Miguel and Santa Rosa wild populations, we calculated the minimum number known to be alive (MNKA) at the end of 2006 as the sum of the number of individuals caught during fall trapping and the number of radiocollared individuals not caught during trapping but known to be alive. At the end of 2006, the MNKA was 80 on San Miguel and 40 on Santa Rosa.

Trap success or trap efficiency, calculated as the percentage of traps occupied by foxes, was higher on San Miguel than on Santa Rosa, both for overall fox captures and individuals.

All captive foxes, including those released to the wild, were vaccinated against canine distemper virus and rabies. Additionally, all foxes captured during fall trapping efforts were vaccinated. All 40 foxes known to be alive on Santa Rosa were vaccinated. On San Miguel, 71 of the 80 foxes known to be alive were vaccinated.

### Captive Breeding

During 2006, island foxes were held in captivity on San Miguel and Santa Rosa Islands for the purpose of captive breeding and release to the wild. New pairings were implemented for captive island foxes in November 2006, according to the recommendations of the AZA's population management plans for those subspecies of island foxes. On San Miguel Island, 2 existing pairs were broken up, and 1 new pair was created. On Santa Rosa Island, 1 existing pair was broken up, and 7 new pairs were created. By the end of 2006 there were 16 foxes in captivity on San Miguel, including 7 pairs, and 28 on Santa Rosa, all of which were paired.

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 rabies. Captive animals requiring treatment for injuries or other ailments were given veterinary care as required.

Productivity in the San Miguel captive program is low, particularly in comparison to productivity in the wild. In 2006, the 12 captive Miguel females produced 6 pups, whereas the 15 wild females produced at least 32 pups. For this reason, as well as the high survival in the wild, we anticipate closing the San Miguel captive breeding facility after releases in fall 2007. Individuals that are likely to fail in captivity are more likely to breed successfully in the wild, thereby making the wild a better place to invest foxes.

On the other hand, we anticipate operating the Santa Rosa captive facility indefinitely, due to several factors:

- Survival in the wild (49%) is lower than on San Miguel (84%), and is less than the level (80%) required for a stable or increasing population;
- The primary mortality factor in the wild, eagle predation, may be unresolved;
- Non-native deer and elk will remain on the island until 2011, and may attract and support golden eagles; and
- Reproductive success in the wild (1.4 pups/female) is less than that on San Miguel (2.1 pups/female).

**Table 1. Summary statistics for wild and captive island fox populations, San Miguel and Santa Rosa Islands, 2006.**

|                                     | San Miguel | Santa Rosa |
|-------------------------------------|------------|------------|
| <i>Wild Population</i>              |            |            |
| MNKA                                | 80         | 40         |
| Annual survival                     | 84%        | 49%        |
| Mortalities of radiocollared foxes  | 6          | 20         |
| Trap efficiency                     |            |            |
| Captures                            | 40.8%      | 12.4%      |
| Individuals                         | 17.1%      | 5.2%       |
| Recruitment                         |            |            |
| Pups                                | 32         | 14         |
| Pups/female                         | 2.1        | 1.4        |
| <i>Captive Population</i>           |            |            |
| Founders                            | 8          | 12         |
| Recruitment                         |            |            |
| Pups                                | 6          | 9          |
| Pups/female                         | 0.5        | 0.6        |
| Released                            | 16         | 13         |
| Left in captivity                   | 16         | 28         |
| Pairs for 2006-2007 breeding season | 7          | 14         |

#### Removal of Golden Eagles

Two adult golden eagles were captured on Santa Cruz Island in June 2006. The Nature Conservancy conducted a helicopter net-gun capture operation that succeeded in capturing both the male and female of a breeding pair which had evaded ground-capture attempts at the nest-site. Prior to their capture, the golden eagle pair, which had nested in Laguna Canyon, was responsible for the deaths of approximately a dozen island foxes, including several radiocollared foxes. After capture, the lone eaglet in the nest was removed by hand and released from a hacking tower near San Diego. The adults were transported to northeastern California and released.

#### Other Management Actions Required for Fox Recovery

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. Removal of the island's approximately 6,000 pigs was completed by 2007.

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 program, in which up to 12 young bald eagles were released on Santa Cruz Island annually from 2002-2006. By the end of 2006 approximately 30 bald eagles resided on Santa Cruz and Santa Rosa Islands. Additionally, two pairs of bald eagles each fledged a chick from a Santa Cruz Island nest in 2006, representing the first successful bald eagle nesting attempts on the northern Channel Islands since 1949.

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. Captive island foxes produced 21 pups in captivity on Santa Cruz in 2006, bringing the captive population to 84 foxes. A total of 56 captive foxes were released to the wild in 2006, with 24 foxes remaining in captivity.



*Male M23, released 2 October, 2006 in Quemada Canyon, Santa Rosa Island*

## 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 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 allowed golden eagle colonization of the islands (Roemer et al. 2001a). Island foxes evolved in the absence of significant diurnal aerial predators such as 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, and consensus was 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 2006, 44 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 2005 and 2006 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.



*Wild island fox, Santa Cruz Island*

*Cathy Schwemm*

## **Captive Breeding Program Development**

Captive breeding was identified as emergency recovery action required to prevent extinction of island foxes on the northern Channel Islands (Coonan and Rutz 2001). The Park's island fox recovery strategy (Coonan 2003) also identified captive breeding as a critical recovery element necessary to recover island fox populations to viable levels on the northern Channel Islands.

### ***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, 2005a, 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 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.

**Table 2. Basic diet for captive island foxes.**

| Tuesday       | Wednesday    | Thursday     | Friday       | Saturday     | Sunday       | Monday       |
|---------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 1/2 C kibble* | 1/4 C kibble | 1/2 C kibble | 1/2 C kibble | 1/2 C kibble | 1/2 C kibble | 1/2 C kibble |
|               |              |              | 1/2 Egg      |              | 1/2 Egg      |              |
|               | Fruit        |              | Fruit        |              | Fruit        |              |
| Insect        | Insect       | Insect       | Insect       | Insect       | Insect       | Insect       |
| Mouse         |              |              |              | Mouse        |              |              |
|               |              |              |              |              |              | Nuts / Seeds |
|               | Quail        |              |              |              |              |              |
| Starch        |              | Starch       |              | Starch       |              | Starch       |
|               | Vegetables*  |              | Vegetables   |              | Vegetables   |              |

\* Non-reproductive diet: 2:1 ratio of adult dog and adult cat kibble; reproductive diet: 2:1 ratio of puppy and kitten kibble

### Diet

In 2006 a new captive fox diet (Table 2) was implemented in order to better manage weight problems in captive foxes. The new diet was based upon the Santa Barbara Zoo's island fox diet (designed by Dr. Karl Hill). The new diet introduced 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 (Science Diet Adult Dog; Hill's Pet Nutrition, Topeka, KS) and adult cat kibble (Science Diet Cat) 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 (Science Diet Puppy) and kitten (Science Diet Kitten) kibble, and the amounts of supplements are increased.

## Overall Breeding Success

Reproductive success among captive island foxes on San Miguel and Santa Rosa was poor (Table 3), comparable to that in 2005, and was less than that of captive Santa Cruz Island foxes. In March 2006, Drs. Winston Vickers and Deana Clifford performed pregnancy testing on captive foxes, via ultrasound, and the results suggest sources of reproductive failure. On San Miguel reproductive failure resulted primarily from failure to conceive, in addition to some perinatal pup loss. Only 5 of 12 pairs became pregnant, and two of those pairs lost litters. On Santa Rosa, the rate of perinatal loss was high. Twelve of 16 pairs became pregnant, but 21 of 30 pups observed on ultrasound were lost. Some as-yet unidentified source of stress may be a factor in the Santa Rosa perinatal pup loss (W. Vickers, Institute for Wildlife Management, pers. comm.).

As in previous years, juvenile females and those animals paired for the first time generally did not breed. None of 4 paired juvenile females bred. Only three of 15 pairs which were paired for the first time successfully produced a litter.

**Table 3. Reproductive success among captive island foxes on the northern Channel Islands, 2005-2006.**

|            | 2005          |      |          | 2006          |      |          |
|------------|---------------|------|----------|---------------|------|----------|
|            | Litters/pairs | Pups | Per pair | Litters/pairs | Pups | Per pair |
| San Miguel | 6/18 (33%)    | 10   | 0.55     | 3/12 (25%)    | 6    | 0.50     |
| Santa Rosa | 4/19 (21%)    | 8    | 0.42     | 5/16 (31%)    | 9    | 0.56     |
| Santa Cruz | 10/21 (48%)   | 20   | 0.95     | 8/29 (28%)    | 21   | 0.72     |

## 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 (Carlstead 2006). Dr. Kathy Carlstead of the Honolulu Zoo 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. 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.

The primary factor affecting reproductive success among females was being wild-born, and having a wild-born mate. 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.

The study provided the following recommendations:

- Improve the management of captive-born individuals, since the problems with captive-born individuals are behavioral in nature. Socialization with humans at an early age may be required.
- Identify pair incompatibility, which likely results in lost litters and aggression, by signs of food competition, distance between pair members, and different behavioral types.
- Provide cover from the wind, and a large number of diverse pen furnishings.

A second captive fox reproductive study (Sovada 2005) began in 2005. Principal investigators Dr. Cheryl Asa of the St. Louis Zoo and Dr. Marsha 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 2005 and 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).

Sovada et al. (2006) summarized the preliminary findings from the first season of study:

- All observed pairs on Santa Cruz and Santa Rosa spent significant time resting in proximity to each other, suggesting the pairs were compatible
- All pairs also had aggressive encounters
- Video documented mating (copulation) for all pairs on Rosa and Cruz
- Copulatory ties were observed in 2 Miguel pairs, pens M09 and M03

Sovada et al. (2006) then identified several sources of reproductive failure, including failure to conceive, and early embryo and perinatal loss. The authors also remarked on the high incidence of mate aggression, noting that the aggression did not always result in injury, and might be considered normal for the species.

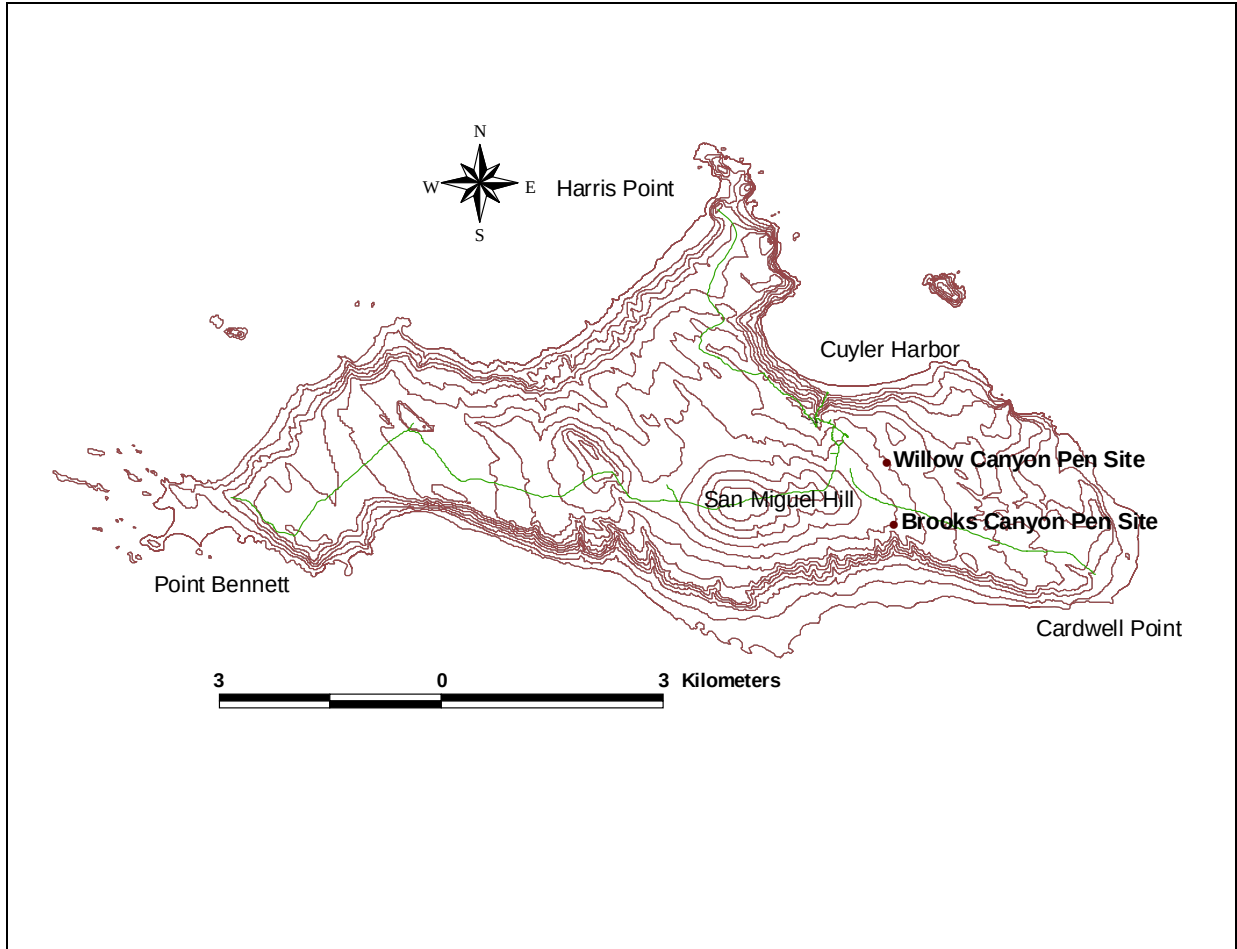


Figure 1. Location of island fox captive breeding facilities, San Miguel Island.

## Recovery of San Miguel Island Foxes

With the birth of 6 pups in spring 2006, and no mortalities, the captive island fox population on San Miguel Island grew to 32 foxes, of which 16 were released to the wild in fall 2006 (Table 4).

### ***Captive Breeding***

On San Miguel, only 3 of 12 captive pairs (25%) produced litters in 2006 (Tables 5-7). Of the 6 pups born in captivity in 2005, 2 were female. No new founders bred in 2006, leaving the number of founders for the San Miguel population at 8. Seven captive-born and 2 wild-born females failed to produce litters in 2006. Three females lost at least 1 pup that had been observed on ultrasound in March.

**Table 4. Growth of captive island fox population, San Miguel Island.**

| Year | Adults          |    |                 | Pups |   |       | Died | Released | Total Captive |
|------|-----------------|----|-----------------|------|---|-------|------|----------|---------------|
|      | F               | M  | Total           | F    | M | Total |      |          |               |
| 2000 | 10              | 4  | 14 <sup>1</sup> | 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 <sup>2</sup> | 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            |
| 2006 | 14              | 12 | 26              | 2    | 4 | 6     | 0    | 16       | 16            |

<sup>1</sup>Founding population

<sup>2</sup>Includes the last wild fox, female 33053, brought into captivity in September 2003; died in December 2003

Reproductive success was low in captivity on San Miguel in 2006, as it was in 2005 (Table 3). Ultrasound testing for pregnancy in March (W. Vickers, Institute for Wildlife Studies, and D. Clifford, University of California, Davis, unpubl. data) indicated that 4 females were pregnant, though the pair in pen M01 subsequently failed to wean any pups. Additionally, a dead pup was found in pen M02 on 14 May, indicating that female's pregnancy was not detected on ultrasound. The ultrasound results suggest that on San Miguel in 2006, reproductive failure was due more to failure to conceive, rather than to neonatal loss of pups.

All captive San Miguel island foxes were given annual veterinary examinations by Dr. Winston Vickers, D.V.M., in September 2006. At time of examination, blood samples were taken from all animals and processed by IDEXX Laboratories (West Sacramento, CA) for hematology and complete blood chemistry. Injuries and other conditions requiring veterinary treatment are summarized in Appendix B. All captive foxes were vaccinated against canine distemper virus and rabies.

Most of the injuries that occurred to San Miguel captive foxes (Appendix B) were due to mate aggression. As in other years, at least one new pair from the pen changes in fall 2005 had to be split up prior to breeding season due to aggression. The only other notable injury was edema that resulted from an overly tight collar on male C311C. As part of the reproductive study, collars were affixed to the males in each of the 5 pens slated for behavioral observation. The edema that subsequently occurred in C311C was treated with an anti-inflammatory steroid, and the collar was loosened, and ultimately removed, after a second incident of edema.

To prevent occurrence of mastitis in captive breeding females, all females which were pregnant or nursing, or suspected to be pregnant, were given an antibiotic (Amoxycillin) as a preventative during breeding season.

Colleen Lynch of the AZA's Population Management Center provided us with recommendations for genetic management of the captive population in summer 2006. Accordingly, in November 2006 2 existing pairs were broken up, and 1 new pair was created. There are currently 16 foxes in captivity, of which 14 are paired (Appendix B). Two female foxes >10 years old are not paired. The 16 foxes remaining in captivity are all housed at the Willow Canyon facility in order to reduce staff workload (staffing on San Miguel is half that in previous years, due to declining budgets). The Brooks Canyon facility currently houses no foxes.

**Table 5. Reproductive success of captive San Miguel Island foxes, 2005-2006 breeding season.**

| Pen | PitTag | Studbook Number | Sex | Born    | Age | Paired     | Result    | Litter Size | Pups on Ultrasound |
|-----|--------|-----------------|-----|---------|-----|------------|-----------|-------------|--------------------|
| M01 | 87F53  | 133             | M   | Captive | 4   |            |           |             |                    |
|     | 85764  | 135             | F   | Captive | 4   | 11/2/2002  | No Litter |             | 2                  |
| M02 | E4B2D  | 237             | M   | Captive | 2   |            |           |             | *                  |
|     | C5D00  | 231             | F   | Captive | 2   | 12/14/2005 | No Litter |             |                    |
| M03 | 7574A  | 32              | M   | Wild    | 8   |            |           |             |                    |
|     | 92C32  | 31              | F   | Wild    | 8   | 7/16/1999  | No Litter |             |                    |
| M04 | 11F73  | 79              | M   | Captive | 5   |            |           |             |                    |
|     | F6558  | 49              | F   | Wild    | 7   | 10/17/2002 | No Litter |             |                    |
| M07 | 94714  | 268             | M   | Captive | 1   |            |           |             |                    |
|     | 52249  | 227             | F   | Captive | 2   | 12/14/2005 | No Litter |             |                    |
| M09 | C311C  | 165             | M   | Captive | 3   |            |           |             |                    |
|     | 2033F  | 270             | F   | Captive | 1   | 12/14/2005 | No Litter |             |                    |
| M10 | 57150  | 35              | M   | Wild    | 8   |            |           |             |                    |
|     | 3167E  | 271             | F   | Captive | 1   | 12/14/2005 | No Litter |             |                    |
| M11 | 47B06  | 63              | M   | Captive | 6   |            |           |             |                    |
|     | E2677  | 36              | F   | Wild    | 8   | 10/17/2000 | Litter    | 3           | 3                  |
| M18 | C4A16  | 82              | M   | Captive | 5   |            |           |             |                    |
|     | 71071  | 46              | F   | Wild    | 7   | 10/17/2001 | Litter    | 1           | 2                  |
| M19 | 07541  | 266             | M   | Captive | 1   |            |           |             |                    |
|     | 11929  | 62              | F   | Captive | 6   | 12/14/2005 | No Litter |             |                    |
| M21 | 85D02  | 47              | M   | Wild    | 7   |            |           |             |                    |
|     | 90C7D  | 168             | F   | Captive | 3   | 10/24/2004 | No Litter |             |                    |
| M22 | E666D  | 167             | M   | Captive | 3   |            |           |             |                    |
|     | B0B25  | 48              | F   | Wild    | 7   | 10/24/2004 | Litter    | 2           | 3                  |

\*no pups detected on ultrasound, though a dead pup was found in the pen on 05/14/2006

**Table 6. Island fox pups born in captivity, San Miguel Island, 2006.**

| PitTag | Studbook Number | Sex | Pen | Sire  | Dam   |
|--------|-----------------|-----|-----|-------|-------|
| E381B  | 335             | M   | M11 | 47B06 | E2677 |
| 25A56  | 334             | M   | M11 | 47B06 | E2677 |
| 83630  | 333             | M   | M11 | 47B06 | E2677 |
| C4C41  | 336             | F   | M18 | C4A16 | 71071 |
| F4B39  | 337             | F   | M22 | E666D | B0B25 |
| C2E6D  | 338             | M   | M22 | E666D | B0B25 |

## Reintroduction

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 fall 2004 all survived their first year post-release, and the 4 females released all produced litters in the wild in spring 2005. A second release was conducted in fall 2005, and 15 of the 16 foxes released in 2005 survived through 2006. Remote camera tracking indicated that at least 12 wild females produced litters in 2006, and subsequent trapping in the fall confirmed that at least 32 pups were recruited into the wild population.

Because survival was high in the wild (see below) and reproduction in the wild outstripped that in captivity, NPS proposed releasing half the San Miguel captive population to the wild in 2006 (Coonan and Dennis 2006b). Sixteen foxes (9 males, 7 females) were released to the wild between 17 October and 16 November, 2006, at a total of 4 release sites on San Miguel Island (Table 7). As of 1 May 2007, 14 of the 16 released foxes were alive, with functioning radiocollars. One radiocollar (M228) had failed, and one fox (M233) died of unknown causes. The cause of mortality is unknown for the one fox that died following release, though necropsy revealed marked emaciation. The fox had lost approximately 1.0 kg in the 3 weeks since release.

**Table 7. Island foxes released to the wild, San Miguel Island, 2006.**

| PitTag | ID   | Sex | Age | Born <sup>1</sup> | Released   | Release Site   | Type <sup>2</sup> | Fate          |
|--------|------|-----|-----|-------------------|------------|----------------|-------------------|---------------|
| 57150  | M226 | M   | 8   | W                 | 10/17/2006 | Nidever Canyon | Gr                | In wild       |
| 94714  | M225 | M   | 1   | C                 | 10/17/2006 | Nidever Canyon | Gr                | In wild       |
| C2E6D  | M229 | M   | 0   | C                 | 11/7/2006  | West End Dunes | Fa                | In wild       |
| F4B39  | F322 | F   | 0   | C                 | 11/7/2006  | West End Dunes | Fa                | In wild       |
| 90C7D  | F321 | F   | 3   | C                 | 11/7/2006  | West End Dunes | FP                | In wild       |
| 85D02  | M228 | M   | 7   | W                 | 11/7/2006  | West End Dunes | FP                | Collar failed |
| 11F73  | M230 | M   | 5   | C                 | 11/11/2006 | Liberty Hill   | SP                | In wild       |
| F6558  | F323 | F   | 7   | W                 | 11/11/2006 | Liberty Hill   | SP                | In wild       |
| 83630  | M231 | M   | 0   | C                 | 11/12/2006 | Dry Lakebed    | Fa                | In wild       |
| 25A56  | M232 | M   | 0   | C                 | 11/12/2006 | Dry Lakebed    | Fa                | In wild       |
| C4C41  | F324 | F   | 0   | C                 | 11/12/2006 | Dry Lakebed    | Gr                | In wild       |
| 52249  | F325 | F   | 2   | C                 | 11/12/2006 | Dry Lakebed    | Gr                | In wild       |
| 7574A  | M233 | M   | 8   | W                 | 11/15/2006 | Liberty Hill   | SP                | d. 12/06/2006 |
| 92C32  | F326 | F   | 8   | W                 | 11/15/2006 | Liberty Hill   | SP                | In wild       |
| E381B  | M234 | M   | 0   | C                 | 11/16/2006 | Liberty Hill   | Gr                | In wild       |
| 11929  | F327 | F   | 6   | C                 | 11/16/2006 | Liberty Hill   | Gr                | In wild       |

<sup>1</sup>W = wild, C = captive

<sup>2</sup>Gr = group, Fa = family group, FP = failed pair, SP = successful pair

## **Monitoring**

In 2006 we conducted mortality monitoring via radiotelemetry on San Miguel and Santa Rosa Islands, in order to estimate annual survival of island foxes, and to identify mortality sources. We monitored wild populations via transect trapping on both islands, and investigated the use of small grids as a population monitoring tool on San Miguel. On both islands we monitored the reproductive success of wild island foxes with activity-triggered remote cameras deployed near densites.

## **Methods**

Mortality-sensing radio-telemetry collars were placed on all foxes released to the wild and on other wild foxes (such as wild-born pups) in order to assess mortality rates and factors. Collared foxes were monitored regularly to determine their general location and signal type (normal or mortality). If a mortality signal was detected, the dead fox was located and recovered. Data collected at the site prior to removing the carcass included: 1) recording any information that might indicate cause of mortality, 2) the position of the carcass with respect to its surroundings, including digital photographs, and 3) the general condition of the animal (e.g., eviscerated, intact, damage by insect scavengers, etc.). The location of the carcass was recorded via GPS, and a general description of the habitat was recorded.

Carcasses were tagged with pertinent identification, date and location information. If a carcass could be brought to the mainland within 48 hours of being located, it was refrigerated; otherwise it was frozen and then shipped by overnight carrier to the UC Davis, Wild Carnivore Pathology Laboratory (Dr. Linda Munson) for necropsy. Because freezing of tissues increases autolysis, and therefore decreases data that can be extracted from histological examinations, it is advantageous to have the animal necropsied as soon as possible after death and to avoid freezing if possible. If disease was suspected in the death of the animal, tissues were prepared for histological analysis by UC Davis veterinary staff.

While monitoring for status and activity, we also obtained periodic telemetry-based locations on individual foxes for the purpose of determining home range or use area size and configuration. Delineating home range helps identify known mated pairs of foxes and possible denning areas, provides general information to evaluate use of habitat by foxes, and provides a means of calculating density of foxes in different areas and habitat types on the island. Data were collected and later plotted using the GIS software ArcView (ESRI, Redlands, CA).

Annual survival of radiocollared 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). We calculated an 80% confidence interval about the annual survival rate, as the 95% confidence interval is too conservative (V. Bakker, University of California, Davis, and D. Doak, University of California, Santa Cruz, pers. comm.).

We monitored island fox populations on San Miguel and Santa Rosa Island via transect trapping (both islands) and small grids (San Miguel only). The purpose of the monitoring was to:

- assess condition of individual foxes
- replace radiocollars or affix new radiocollars as required
- vaccinate foxes against canine distemper virus and rabies
- estimate abundance via trap efficiency and the minimum number known to be alive (MNKA), and
- for the San Miguel grids, to estimate density and islandwide population.

Trapping was conducted from October through December, by which time pups had reached adult size and some had dispersed from their natal territories. Box traps (23 by 23 by 66 cm, Tomahawk Live Trap Co., Tomahawk, WI) were baited with dry and wet cat food and a fruit scent (Knob Mountain Raw Fur Co., Berwick, PA). Captured foxes were protected from the elements by careful placement of traps, and by a shade cloth cover on each trap. A polyethylene tube chew bar was wired inside each trap to reduce incidence of tooth damage. Traps were checked once, in the morning, during every 24-hr period.

Upon first capture, animals were weighed in the trap, and then removed and handled without anesthesia for a complete work-up. Data collected included sex, reproductive status, age class, and general physical condition (e.g., condition of coat, presence of ectoparasites, injuries). Captured foxes were marked with passive integrated transponder (PIT) tags (Biomark, Boise, ID) inserted subcutaneously between and just anterior to the scapulae. Single-use sterile PIT tag applicators were used in order to minimize transfer of pathogens. Prior to insertion of the PIT tag, the insertion site was cleaned and disinfected with alcohol, and antibacterial ointment was applied to the needle.

Upon first capture, or once a year thereafter, a blood sample was collected from the femoral or jugular vein of captured foxes, separated into its component fractions by centrifugation, and stored for later genetic and serologic analyses. Up to 10 ml of blood was collected from adult (>1.25 kg) foxes, and up to 5 ml from pups. Staff taking blood samples have had previous experience in drawing blood, and are supervised by permitted individuals while collecting blood from island foxes. Blood samples were analyzed for serum chemistry and complete blood count by IDEXX Laboratories (West Sacramento, CA).

All trap location coordinates (with or without fox captures) were obtained by a geographical positioning system (GPS) receiver and entered into a database for later spatial analysis using geographic information system (GIS) software. Trapping data was used to estimate distribution and abundance of island foxes, through such measures as trapping success, age structure and sex ratio of foxes, and reproductive success (ratio of number of pups to number of adult females). Reproduction was also monitored via remote cameras near densites. 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 late May to early June (when pups emerge from dens) to record the number of pups weaned from each litter. Each camera station included a box trap (23 by 23 by 66 cm, Tomahawk Live Trap Co., Tomahawk, WI), wired open and baited with dog kibble. A digital camera (Digital Scout, Penn's Woods Products, Inc., Export, PA) recorded fox activity in or near the trap when triggered by a passive infrared detector.

To estimate density and islandwide population, 4 small (3 x 6) grids were trapped on San Miguel, one per week for 4 weeks in October 2006. The grids were randomly distributed along the primary east-west cross-island trail (Fig. 2). For each grid, one line of traps was dispersed along the trail at 250-m intervals, with another line of traps directly north and south of each trap-point on the trail. The grids were designed to be relatively easy to set up and trap, so that a 2-person crew could trap one grid per week while still performing other duties (captive fox care, monitoring radiocollared foxes).

Capture data from each grid was analyzed via program DENSITY (Efford et al. 2004) and density was estimated using both conventional methods and inverse prediction. Average density from the 4 grids was multiplied by island size to estimate islandwide fox population size. This was compared to the minimum number of foxes known to be alive prior to fall releases. Both the standard error for the average density and the standard error for the islandwide population estimated were calculated via the delta method (Cooch and White 2006).

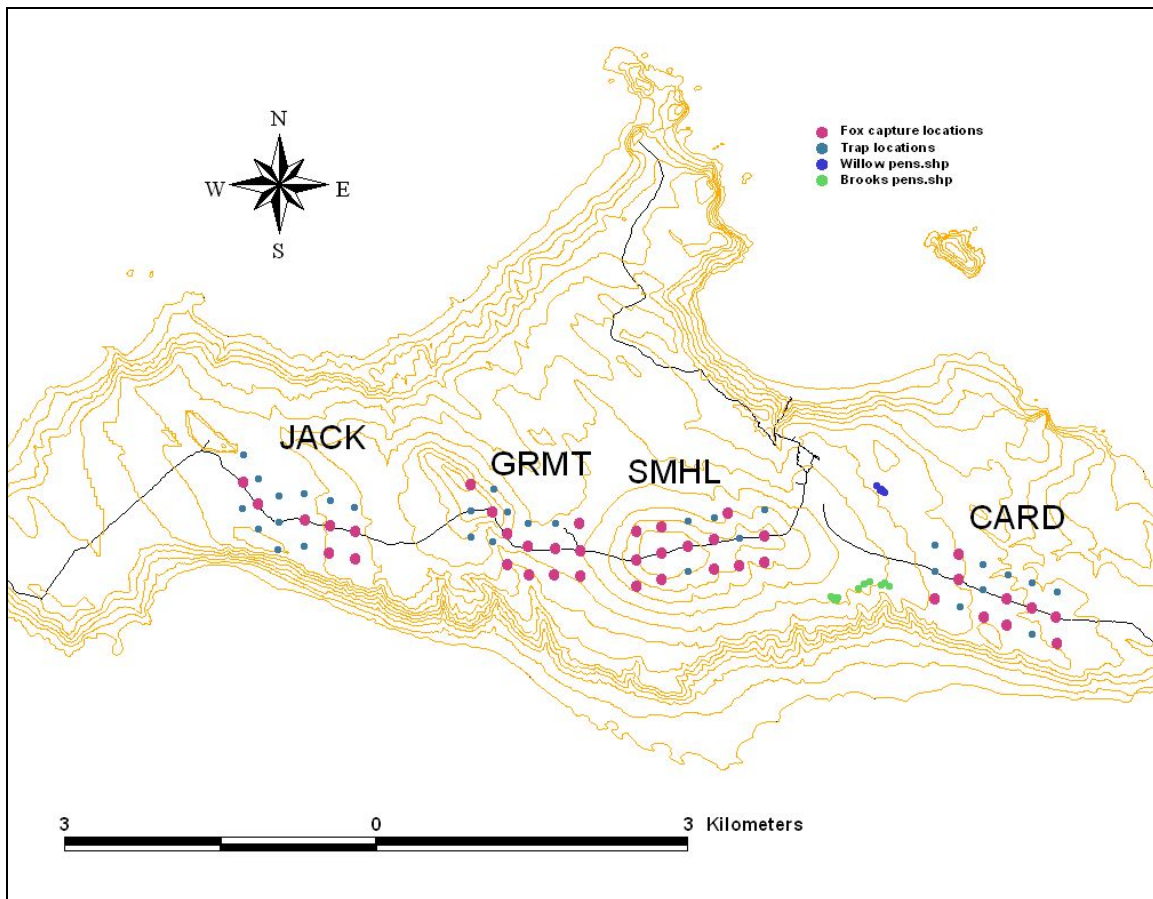


**Figure 2. Locations of trap sites and fox captures for the grids trapped October-November 2006, San Miguel.**

Fox abundance was also measured by estimating trap efficiency, which is the number of fox captures or individuals divided by the number of available traps. The latter does not include traps that were found to be closed when checked.

## Mortality Monitoring

Throughout 2006 we maintained a sample of 36-40 radiocollared foxes on San Miguel. Collared foxes included those released from captivity and some wild-born foxes. Annual Kaplan-Meier survival for San Miguel island foxes in 2006 was 84% (80% CI = 77-91%). An annual survival rate of 80% has been estimated to be required for a stable or increasing fox population (Roemer et al. 2001b).

Six radiocollared San Miguel Island foxes died in 2006 (Table 8, Fig. 3), one from golden eagle predation. At least one golden eagle was observed on San Miguel Island at the time of the predation-caused mortality. The mortality was the first due to golden eagle predation on San Miguel since the last stages of the islandwide decline, in 1999.

Two other carcasses were emaciated, and 2 mortalities may be due to injuries from aggressive interactions with other wild foxes. One fox (F318) died from complications due to a trichobezoar, a bolus of ingested fur which impeded ingestion, breathing and circulation. The only other occurrence of a trichobezoar was in a wild San Miguel fox that died in 1999 from aspiration pneumonia secondary to obstruction of the esophagus and stomach from a trichobezoar (Coonan et al. 2005b). The fur in the trichobezoar could have come from self-grooming, or it could be deer mouse (*Peromyscus maniculatus*) fur from ingestion of prey. Foxes on San Miguel rely more on deer mice than do foxes on other islands (Collins and Laughrin 1979).

Another radiocollared fox died from complications following a wound that may have been the result of an aggressive encounter with another fox. Male M219 suffered a traumatic injury, likely a bite wound, to the tip of his penis that resulted in adherence of the penis to the prepuce and occlusion of the urethral opening. The inability to urinate caused him to become uremic.

**Table 8. Island fox mortalities, San Miguel Island, 2006.**

| PitTag | ID   | Sex | Born    | Age | Date       | Mortality Cause                                                                                                      |
|--------|------|-----|---------|-----|------------|----------------------------------------------------------------------------------------------------------------------|
| C0934  | F312 | F   | Wild    | 1   | 1/29/2006  | Predation                                                                                                            |
| 90D1A  | F314 | F   | Wild    | 8   | 3/16/2006  | Emaciation and anemia                                                                                                |
| 22A35  | M219 | M   | Wild    | 1   | 6/3/2006   | Uremic poisoning resulting from bite wound to penis which caused occlusion of urethral opening; aspiration pneumonia |
| 13212  | M215 | M   | Captive | 4   | 9/29/2006  | Undetermined, due to autolysis.                                                                                      |
| 30D5F  | F318 | F   | Captive | 1   | 11/27/2006 | Intraesophageal occlusive trichobezoar with emaciation                                                               |
| 7574A  | M233 | M   | Wild    | 8   | 12/6/2006  | Emaciation                                                                                                           |

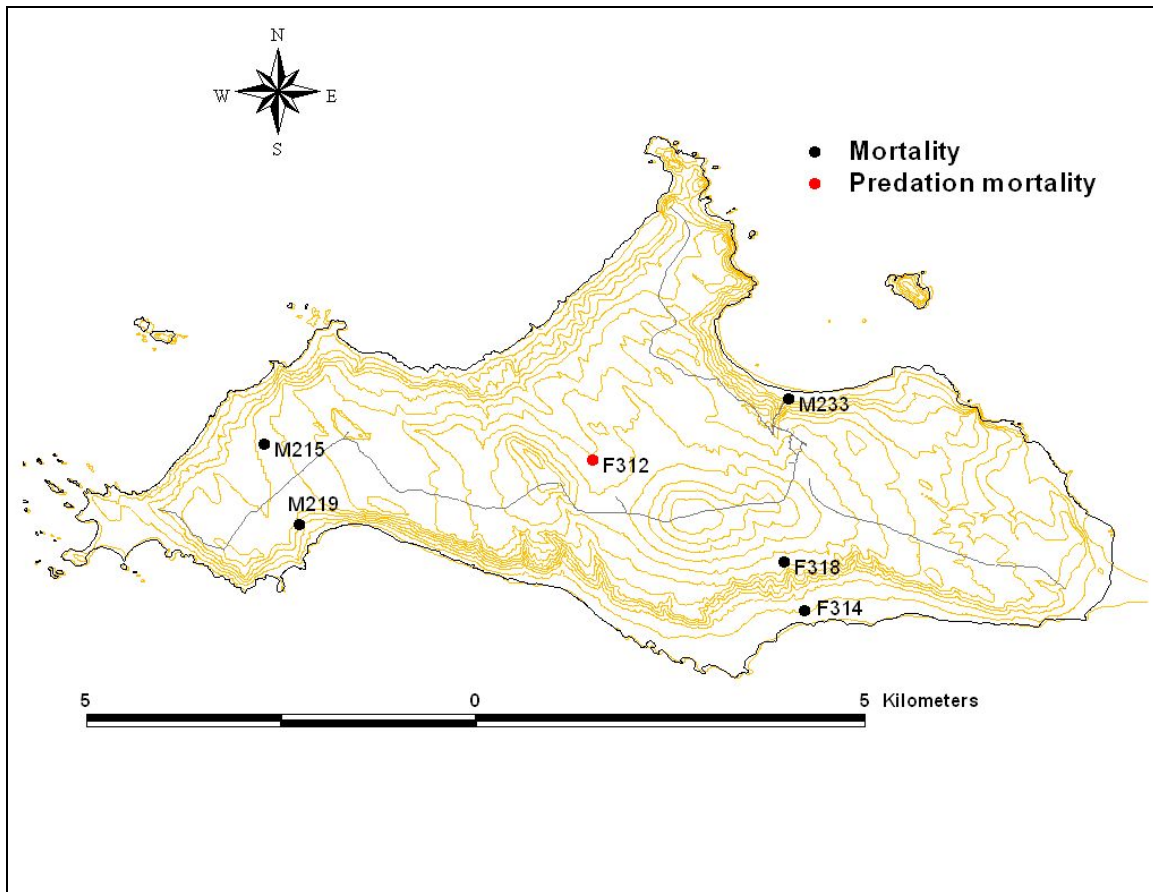


**Figure 3. Mortality locations for released and wild-born island foxes on San Miguel Island, 2006.**

### Population Monitoring

From May through August 2006 we deployed remote cameras near likely densites to monitor reproductive success (number of pups weaned) for 13 pairs on San Miguel Island (Table 9, Fig. 4). A total of 25 pups were observed in 12 of the 13 territories. All 5 juvenile females produced litters, as did 8 of the 9 captive born females. This stands in contrast to reproductive success in captivity, where juvenile females and captive-born animals have not reproduced well (Carlstead 2006, Coonan and Dennis 2005).

Transect and grid trapping in fall 2006 yielded the following measures of population health:

- Minimum number of foxes known to be alive (MNKA)
- Islandwide population estimate
- Reproductive effort
- Individual health, as indicated by body weight

**Table 9. Number of pups observed via remote camera for 13 island fox pairs, San Miguel Island, June-August 2006.**

| Pair# | Female | Female Born | Female Age | Male | Male Born | Male Age | Pups Observed |
|-------|--------|-------------|------------|------|-----------|----------|---------------|
| M0601 | F301   | Captive     | 2          | M201 | Captive   | 5        | 1             |
| M0602 | F302   | Captive     | 2          | M203 | Captive   | 4        | 1             |
| M0603 | F304   | Captive     | 2          | M205 | Captive   | 2        | 3             |
| M0604 | F303   | Captive     | 2          | M206 | Captive   | 3        | 1             |
| M0605 | F305   | Captive     | 3          | M202 | Captive   | 4        | 2             |
| M0606 | F308   | Captive     | 4          | M209 | Captive   | 3        | 0             |
| M0607 | F313   | Captive     | 2          | M214 | Captive   | 4        | 2             |
| M0608 | F306   | Captive     | 3          | M223 | Wild      | 1        | 2             |
| M0609 | F309   | Captive     | 1          | M210 | Captive   | 1        | 4             |
| M0610 | F311   | Wild        | 1          | M208 | Captive   | 1        | 1             |
| M0611 | F310   | Wild        | 1          | M207 | Captive   | 3        | 4             |
| M0612 | F316   | Wild        | 1          | M222 | Wild      | 1        | 2             |
| M0613 | F315   | Wild        | 1          | M218 | Wild      | 1        | 2             |

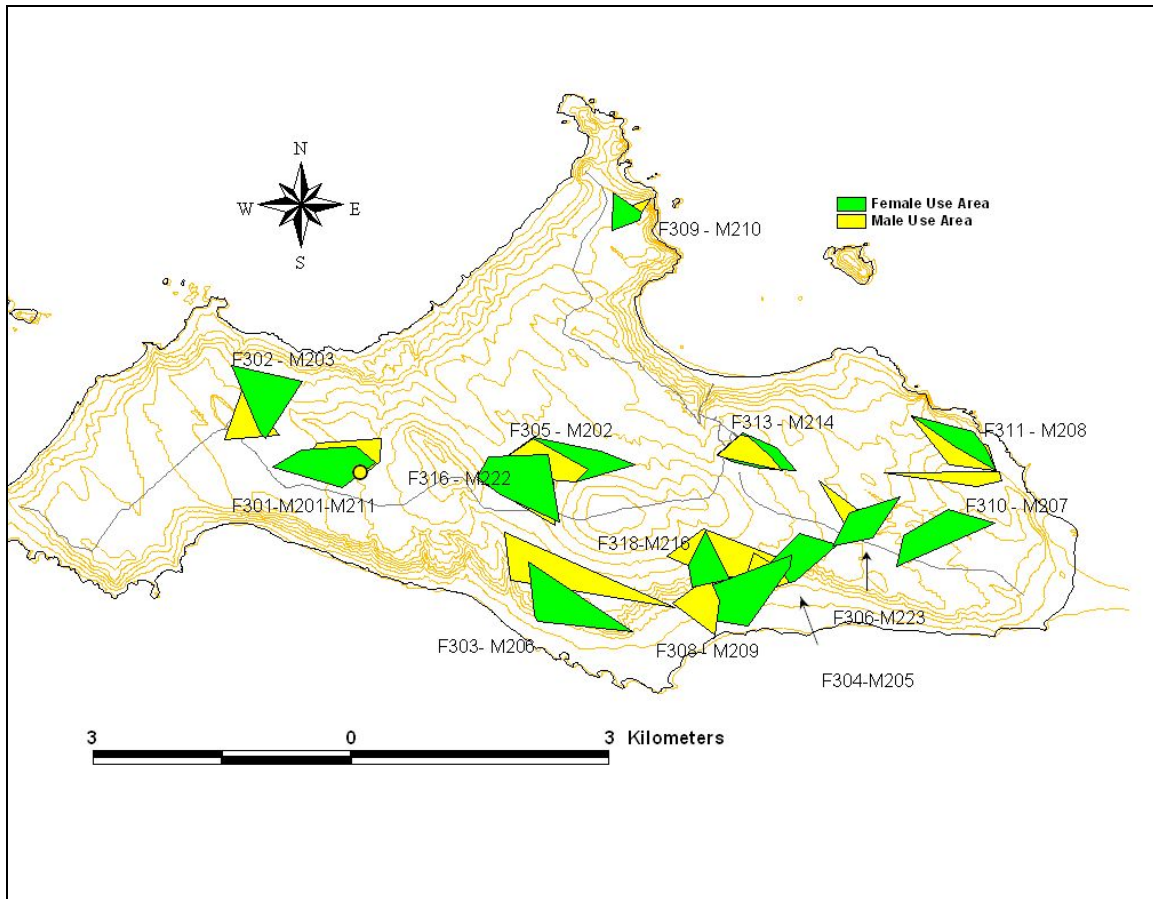


**Figure 4. Breeding season (February-June) use areas for island fox pairs observed with remote cameras, San Miguel Island, 2006.**

**Table 10. Density estimates for small grids, San Miguel Island, 2006.**

| Grid    | Date Trapped  | Individ. | Capture Prob. | Density (foxes/km <sup>2</sup> ) | SE   | ETA <sup>2</sup> (km <sup>2</sup> ) |
|---------|---------------|----------|---------------|----------------------------------|------|-------------------------------------|
| JACK    | 10/11 – 10/13 | 8        | 0.3077        | 1.2                              | 0.50 | 1.1                                 |
| GRMT    | 10/19 – 10/22 | 17       | 0.3295        | 3.1                              | 1.10 | 0.9                                 |
| SMHL    | 10/26 – 10/29 | 14       | 0.5357        | 1.5                              | 0.48 | 1.1                                 |
| CARD    | 11/02 – 11/05 | 8        | 0.3889        | 1.1                              | 0.80 | 1.2                                 |
| average |               |          |               | 1.7                              | 0.38 |                                     |

<sup>1</sup>JACK = Jackass Flats, GRMT = Green Mountain, SMHL = San Miguel Hill, CARD = Cardwell Point

<sup>2</sup>estimated trapping area

The 4 small grids were trapped from mid-October to early November (Table 10, Fig. 2), and the transects from mid-November to late December (Fig. 5). A total of 72 individuals were trapped, 39 on the grids and 39 on the transects. The minimum number known to be alive (MNKA) at the end of 2006 was the sum of the number of individuals caught during fall trapping (72) and the number of radiocollared individuals not caught during trapping but known to be alive (8). At the end of 2006, the MNKA was 80 on San Miguel.

Density on the 4 grids ranged from 1.1-3.1 foxes/km<sup>2</sup>, with the average density, including both adults and pups, being 1.7 foxes/km<sup>2</sup> (Table 10). The coefficient of variation for the islandwide density estimate was 0.223. A CV < 0.20 is desirable (M. Efford, Landcare Research, pers. comm.).

Multiplying the average density by the area of the island (38.1 km<sup>2</sup>) yielded a population estimate of 65 foxes, with 80% CI = 47-84. The islandwide estimate of 65 foxes is similar to the minimum number known to be alive when grid trapping ceased in early November (66 foxes). The MNKA for that time is estimated as the MNKA for the year (80) minus the number of foxes released after grid trapping ceased (14).

The annual rate of increase from 2005 to 2006 is calculated as the number of foxes known to be alive prior to 2006 releases (64) divided by the number of foxes known to be alive at the end of 2005 (40; Coonan and Dennis 2006a). The estimated lambda of 1.6 indicates an increasing population.

We tallied foxes by sex and age for both the grid trapping and transect trapping efforts, as well as the combined effort (Table 11). The adult population was slightly biased toward males, as were the number of pups born in the wild (18 M:14 F). A total of 32 wild-born pups were caught, of which 6 were subsequently radiocollared (Table 12). We measured reproductive success as the ratio of pups (32) to number of known adult females in spring 2006 (15). The estimated reproductive success of 2.1 pups/female was relatively high, compared to values from other years (including data from 1993-1999, encompassing the population decline) (Table 13). A regression of reproductive effort on adult population size showed reproductive effort declining as population increases, an apparent density-dependent effect (Fig. 6).

Trap success or trap efficiency, measured as either the number of captures or number of individuals per available traps, was 40.8% (captures) and 17.1% (individuals) in fall 2006 (Table 14). The 2006 San Miguel trap efficiency values were higher than those in 2005 (captures, 19.3%, individuals, 11.6%, T. Coonan, National Park Service, unpubl. data) and were over 3X higher than 2006 values for Santa Rosa.

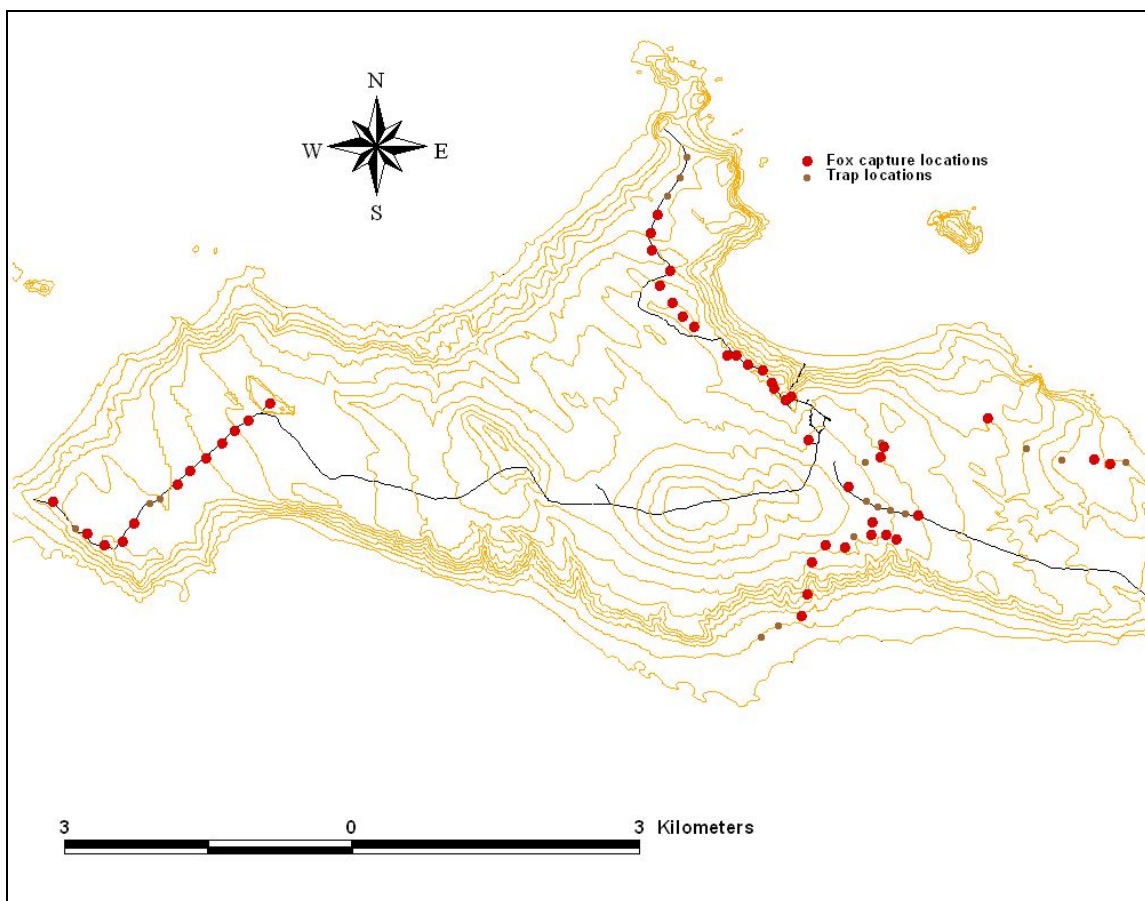


**Figure 5. Locations of traps and fox capture locations on transects trapped November-December, 2006, San Miguel Island.**

**Table 11. Sex and age distribution of foxes trapped on both grids and transects, San Miguel Island, October-December 2006.**

|                   | Grids | Transects        | Combined         |
|-------------------|-------|------------------|------------------|
| Adult Males       | 11    | 11               | 20               |
| Adult Females     | 8     | 9                | 16               |
| Male:Female ratio | 1.4:1 | 1.2:1            | 1.3:1            |
| Male Pups         | 12    | 12               | 21               |
| Female Pups       | 8     | 7                | 15               |
| Total Pups        | 20    | 19               | 36               |
| Pups/Female       | 2.5   | N/A <sup>1</sup> | N/A <sup>1</sup> |

<sup>1</sup>would include pups released from captivity

**Table 12. Island foxes born in the wild on San Miguel Island, 2006, and subsequently caught during fall trapping efforts.**

| PitTag | ID   | Sex | Captured   | PitTag | ID   | Sex | Captured   |
|--------|------|-----|------------|--------|------|-----|------------|
| 86B48  |      | M   | 10/11/2006 | 81142  | M227 | M   | 11/2/2006  |
| 01C16  |      | F   | 10/12/2006 | 4514E  |      | F   | 11/2/2006  |
| 45A3D  |      | M   | 10/12/2006 | 43338  |      | M   | 11/3/2006  |
| 61518  | M224 | M   | 10/13/2006 | 87677  |      | M   | 11/4/2006  |
| 07C0B  |      | F   | 10/19/2006 | 72803  |      | F   | 11/23/2006 |
| 20F04  | F319 | F   | 10/19/2006 | E677F  |      | M   | 11/23/2006 |
| A4142  |      | F   | 10/19/2006 | D014F  |      | M   | 11/24/2006 |
| B5F62  |      | M   | 10/19/2006 | 87160  |      | F   | 11/30/2006 |
| 13750  |      | M   | 10/19/2006 | 53502  |      | F   | 12/1/2006  |
| 50665  |      | F   | 10/20/2006 | E6574  |      | M   | 12/6/2006  |
| B6376  |      | M   | 10/20/2006 | C1220  |      | M   | 12/6/2006  |
| D2966  | F320 | F   | 10/20/2006 | C6768  |      | F   | 12/7/2006  |
| 55825  |      | M   | 10/21/2006 | 43956  | F328 | F   | 12/22/2006 |
| D5951  |      | F   | 10/27/2006 | F360B  |      | F   | 12/22/2006 |
| 87D68  |      | M   | 10/27/2006 | 8331E  | M235 | M   | 12/22/2006 |
| D1421  |      | M   | 10/29/2006 | 55B30  |      | M   | 1/7/2007   |

**Table 13. Adult population size and reproductive effort for island foxes on San Miguel Island, 1993-2006.**

| Year | Adult Population | Reproductive Effort (pups/adult female) |
|------|------------------|-----------------------------------------|
| 1993 | 305              | 1.15                                    |
| 1994 | 436              | 0.64                                    |
| 1995 | 305              | 0.73                                    |
| 1996 | 101              | 1.75                                    |
| 1997 | 70               | 1.50                                    |
| 1998 | 35               | 2.25                                    |
| 2005 | 10               | 2.50                                    |
| 2006 | 38               | 2.13                                    |

**Table 14. Trap efficiency for fall trapping efforts, San Miguel and Santa Rosa Islands, 2006.**

| Available traps | San Miguel<br>406 |         | Santa Rosa<br>736 |         |
|-----------------|-------------------|---------|-------------------|---------|
|                 | Number            | Percent | Number            | Percent |
| Fox captures    | 166               | 40.8    | 91                | 12.4    |
| individuals     | 72                | 17.1    | 38                | 5.2     |
| Skunk captures  |                   |         | 379               | 51.5    |
| individuals     |                   |         | 269               | 42.1    |

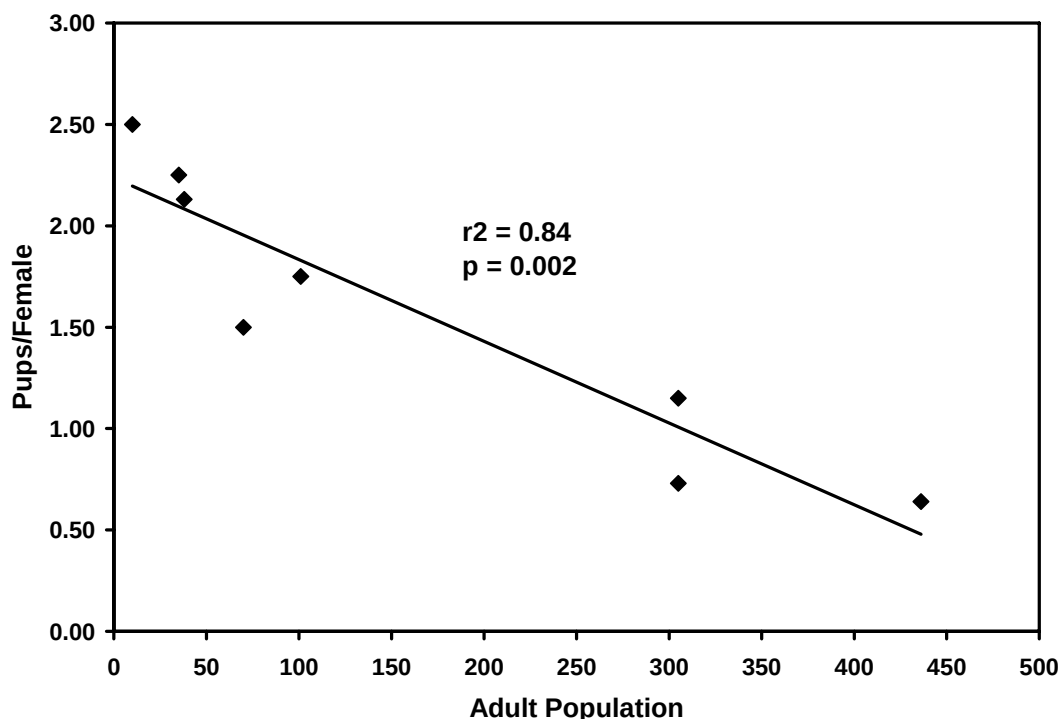


**Figure 6. Reproductive effort (pups/female) versus adult population size, for island foxes on San Miguel Island, 1993-2006.**

### ***Future Plans***

Results from monitoring in 2006 indicate that the wild population on San Miguel is in a phase of rapid expansion. Survival is high, as is reproductive success, and the rate of increase, or lambda, from 2005 to 2006 was 1.6. On the other hand, reproductive success in captivity is relatively low. The 12 paired captive females produced only 6 pups, whereas the 15 wild adult females produced 32 pups. Under these circumstances, a captive population contributes very little to maximizing the population growth of the San Miguel subspecies. Captive foxes which have not bred in captivity or are unlikely to do so are more likely to breed in the wild. For these reasons we are planning on closing the San Miguel captive breeding facility after releases in fall 2007. There are currently 16 foxes in captivity, none of which produced pups spring 2007. In the fall we will release all foxes that are healthy enough to be released. We anticipate there may be 2-4 foxes whose age or health make them unsuitable for release.

The other annual activities authorized under this permit will continue. Pups born in 2007 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 2007. Released animals will be radio-collared and regularly monitored, as will a sample of the wild population. Trapping will be conducted in the fall to estimate population size and reproductive effort.

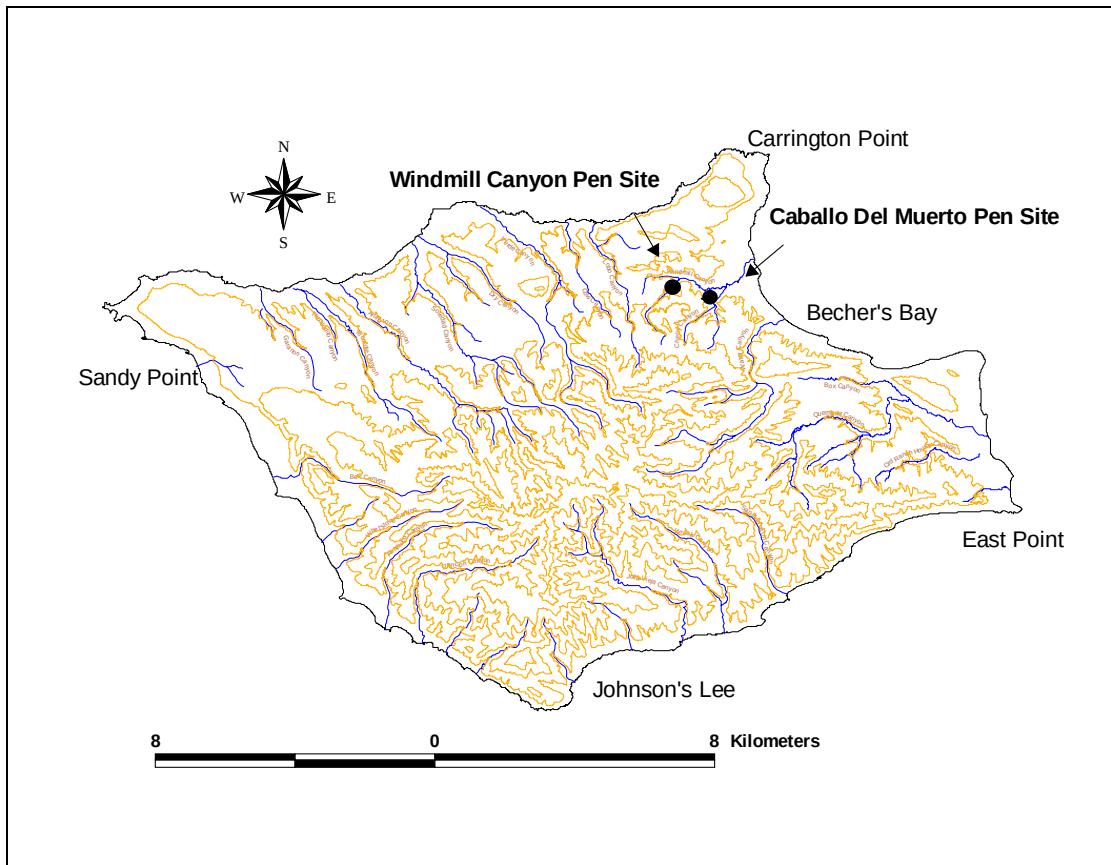


**Figure 7. Location of island fox captive breeding facilities, Santa Rosa Island.**

## Recovery of Santa Rosa Island Foxes

With the birth of 9 pups in spring 2006, the captive island fox population on Santa Rosa Island grew to 43 foxes, of which 13 were released to the wild, one escaped to the wild, and one was transferred to the Santa Barbara Zoo (Table 15). Six foxes released in fall 2006 had died as of 30 April 2007, but none from eagle predation. A total of 20 wild and released foxes died in 2006, 4 from eagle predation. The last predation-caused fox mortality occurred in March 2006. Five foxes that died in fall 2006 were emaciated and had bacterimia and septicemia. Primary pathogens such as *Yersinia* were ruled out by subsequent culture of blood and fecal samples. At least 14 pups were weaned from 4 wild litters in spring 2006. By the end of 2006 the minimum number of foxes known to be alive (MNKA) in the wild on Santa Rosa was 40, half that on San Miguel. A total of 28 foxes, or 14 pairs, remained in captivity.

**Table 15. Growth of captive island fox population, Santa Rosa Island.**

| Year | Adults          |    |                 | Pups           |                |       | Died | Released | Total Captive   |
|------|-----------------|----|-----------------|----------------|----------------|-------|------|----------|-----------------|
|      | F               | M  | Total           | F              | M              | Total |      |          |                 |
| 2000 | 8               | 4  | 12 <sup>1</sup> | 5 <sup>2</sup> | 5 <sup>2</sup> | 10    | 0    |          | 22              |
| 2001 | 14 <sup>3</sup> | 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 <sup>4</sup> |
| 2005 | 22              | 21 | 43              | 2              | 6              | 8     | 0    | 17       | 34              |
| 2006 | 17              | 17 | 34              | 2              | 7              | 9     | 0    | 13       | 28 <sup>5</sup> |

<sup>1</sup>Founding population

<sup>2</sup>Includes 8 pups born in captivity, and 2 pups (1 male, 1 female) born in the wild

<sup>3</sup>An additional female was brought in from the wild on 05/14/2001

<sup>4</sup>Includes 1 female pup born in the wild in spring 2004 and brought into captivity

<sup>5</sup>Male 37E00 transferred to Santa Barbara Zoo on 6/13/2006 and female F4A18 escaped from captivity 5/3/2006

## Captive Breeding

On Santa Rosa, 5 of 16 captive pairs (31%) produced litters in 2006 (Table 16). Of the 9 pups born in captivity in 2006 (Table 17), 7 were male. No new founders bred in 2006, and the number of founders remained at 12. Five captive-born and 6 wild-born females failed to produce litters in 2006.

Reproductive success was low in captivity on Santa Rosa in 2006, as it was in 2005 (Table 3). Ultrasound testing for pregnancy in March (W. Vickers, Institute for Wildlife Studies, and D. Clifford, University of California, Davis, unpubl. data) indicated that 12 of 16 females became pregnant. The ultrasound results suggest that unlike on San Miguel, where only 5 of 12 became pregnant, reproductive failure on Santa Rosa was due to high neonatal loss. The 10 females known to be pregnant in March lost a total of 21 pups to neonatal mortality.

Observers from the reproductive study directed by Dr. Cheryl Asa of the St. Louis Zoo monitored behavior of 8 fox pairs during breeding season (January – June) via pen cameras. All 8 females became pregnant, but only 5 produced litters. Results from the behavior observations and fecal hormone monitoring, as well as the ACTH trials, have yet to be fully analyzed. Sovada et al. (2006) summarized the preliminary findings from the first season of study:

- All observed pairs on Santa Cruz and Santa Rosa spent significant time resting in proximity to each other, suggesting the pairs were compatible
- All pairs also had aggressive encounters
- Video documented mating (copulation) for all pairs on Santa Rosa

Asa et al. (2006) then identified several sources of reproductive failure, including failure to conceive, and early embryo and perinatal loss. The authors also remarked on the high incidence of mate aggression, noting that the aggression did not always result in injury, and might be considered normal for the species.

All captive Santa Rosa Island foxes were given annual veterinary examinations by Dr. Winston Vickers, D.V.M., in June or in September 2006. At time of examination, blood samples were taken from all animals and processed by IDEXX Laboratories (West Sacramento, CA) for hematology and complete blood chemistry. Injuries and other conditions requiring veterinary

treatment are summarized in Appendix B. All captive foxes were vaccinated against canine distemper virus and rabies.

Most of the injuries that occurred to Santa Rosa captive foxes (Appendix B) were due to mate aggression. Three of 11 new pairs, and one established pair, had to be separated prior to breeding season due to aggression. Additionally, 3 pairs had to be separated after or during breeding season.

**Table 16. Reproductive success of captive Santa Rosa Island foxes, 2005-2006 breeding season.**

| Pen | PitTag         | Studbook<br>Number | Sex | Born    | Age | Paired     | Result    | Litter<br>Size | Pups on<br>Ultrasound |
|-----|----------------|--------------------|-----|---------|-----|------------|-----------|----------------|-----------------------|
| R01 | 80C3F          | 222                | M   | Captive | 2   |            |           |                |                       |
|     |                | 149                | F   | Captive | 4   | 10/24/2004 | Litter    | 2              | 4                     |
| R02 | 7235F<br>A5E60 | 219                | M   | Captive | 2   |            |           |                |                       |
|     |                | 265                | F   | Wild    | 2   | 12/11/2005 | Litter    | 2              | 3                     |
| R03 | C4F63<br>A180A | 177                | M   | Captive | 3   |            |           |                |                       |
|     |                | 53                 | F   | Wild    | 6   | 12/11/2005 | Litter    | 2              | 2                     |
| R04 | 64A43<br>D590E | 304                | M   | Captive | 1   |            |           |                |                       |
|     |                | 298                | F   | Captive | 1   | 12/11/2005 | No Litter |                | 3                     |
| R05 | F0223<br>F4A18 | 28                 | M   | Wild    | 8   |            |           |                |                       |
|     |                | 42                 | F   | Wild    | 7   | 10/19/2000 | No Litter |                | 3                     |
| R06 | 0507B<br>D187A | 174                | M   | Captive | 3   |            |           |                |                       |
|     |                | 27                 | F   | Wild    | 8   | 12/11/2005 | No Litter |                | 0                     |
| R07 | 70518<br>10030 | 59                 | M   | Captive | 6   |            |           |                |                       |
|     |                | 26                 | F   | Wild    | 8   | 10/19/2000 | No Litter |                | 3                     |
| R08 | 85420<br>2410E | 224                | M   | Captive | 2   |            |           |                |                       |
|     |                | 54                 | F   | Captive | 6   | 12/11/2005 | Litter    | 1              | 3                     |
| R09 | 32219<br>E485E | 303                | M   | Captive | 1   |            |           |                |                       |
|     |                | 299                | F   | Captive | 1   | 12/11/2005 | No Litter |                | 0                     |
| R10 | B067E<br>47304 | 24                 | M   | Wild    | 8   |            |           |                |                       |
|     |                | 145                | F   | Captive | 4   | 1/30/2004  | Litter    | 2              | 2                     |
| R11 | 73D0D<br>3512D | 44                 | M   | Wild    | 7   |            |           |                |                       |
|     |                | 29                 | F   | Wild    | 8   | 11/5/2000  | No Litter |                | 1                     |
| R12 | 47E09<br>A3B6D | 178                | M   | Captive | 3   |            |           |                |                       |
|     |                | 223                | F   | Captive | 2   | 10/24/2004 | No Litter |                | 2                     |
| R18 | 9230A<br>07061 | 220                | M   | Captive | 2   |            |           |                |                       |
|     |                | 225                | F   | Wild    | 8   | 12/11/2005 | No Litter |                | 2                     |
| R19 | 1271E<br>1612C | 144                | M   | Captive | 4   |            |           |                |                       |
|     |                | 40                 | F   | Wild    | 7   | 12/11/2005 | No Litter |                | 0                     |
| R21 | 97541<br>31049 | 305                | M   | Captive | 1   |            |           |                |                       |
|     |                | 218                | F   | Captive | 2   | 12/11/2005 | No Litter |                | 2                     |
| R22 | B6255<br>A7954 | 302                | M   | Captive | 1   |            |           |                |                       |
|     |                | 170                | F   | Captive | 3   | 12/11/2005 | No Litter |                | 0                     |

**Table 17. Island fox pups born in captivity, Santa Rosa Island, 2006.**

| PitTag | Studbook<br>Number | Sex | Pen | Sire  | Dam   |
|--------|--------------------|-----|-----|-------|-------|
| 90B2D  | 340                | F   | R01 | 80C3F | 25D54 |
| 01262  | 339                | M   | R01 | 80C3F | 25D54 |
| 72269  | 341                | M   | R02 | 7235F | A5E60 |
| C4A1F  | 342                | F   | R02 | 7235F | A5E60 |
| 12270  | 344                | M   | R03 | C4A63 | A180A |
| E5066  | 343                | M   | R03 | C4F63 | A180A |
| 8024B  | 348                | M   | R08 | 85420 | 2410E |
| 3045D  | 350                | M   | R10 | B067E | 47304 |
| B2D61  | 349                | M   | R10 | B067E | 47304 |

One Santa Rosa captive fox was transferred permanently to the Santa Barbara Zoo due to a medical condition that could not be treated effectively in the island breeding facility. Male 37E00 was born in the wild in 2000 and although he had been paired with 2 different females over a period of 5 breeding seasons, he never sired a litter. In 2004 the fox was diagnosed with keratoconjunctivitis sicca (KCS), or “dry eye condition”, an autoimmune disease that prevents the eye from producing adequate tears. The eyes become dry and uncomfortable, and vision gradually decreases to the point of blindness. The condition is not curable. To make the animal comfortable, medication should be applied to the eye several times per day. This type of treatment schedule is not possible in an island-based captive breeding program. Head Curator Alan Varsik and Veterinarian Karl Hill of the Santa Barbara Zoo graciously agreed to assume responsibility for the animal, and the fox was transferred to the zoo on 13 June 2006.

To prevent possible introduction of island parasites to mainland animals, the fox was required to be clear of parasites prior to the move. The period necessary to treat and test the fecal samples was over 3 months (February – June). During that period the fox was tested for fecal parasites three times, and given 3 treatments of Doramectin. The second assay detected *Spirocerca*, a parasite which can cause colonic lesions and death in island foxes (Buckles et al., in prep.). After the third Doramectin treatment the fox was apparently cleared of *Spirocerca*.

To prevent re-occurrence of mastitis in the captive population (Coonan and Dennis 2006a), all females suspected to be pregnant and/or whelping were placed on the antibiotic Amoxicillin in March 2006. One female, F4A18, was diagnosed with mastitis in late April and placed on strong antibiotics (Baytril). She escaped from the foxpital on 2 May 2006, and was trapped in the Jolla Vieja area in October 2006, at which point she was radiocollared as F137.

Colleen Lynch of the AZA’s Population Management Center provided us with recommendations for genetic management of the captive population in summer 2006. Accordingly, in November 2006, one existing pair was broken up, and 7 new pairs were created. There are currently 28 foxes, or 14 pairs, in captivity on Santa Rosa Island (Appendix A).

With the reduced number of foxes in captivity, coupled with the existence of the wild population, there is no longer a need to house foxes in two separate facilities. Therefore in fall 2006 the Caballo del Muerto breeding facility was closed, and all remaining foxes moved to the Windmill Canyon facility.

## Reintroduction

Annual releases to the wild have been conducted on Santa Rosa since 2003. In 2006, 13 foxes (9 males, 4 females) were released to the wild between 27 September and 18 October, 2006, at a total of 3 release sites on Santa Rosa Island (Table 18). Of the 6 releasees that subsequently died, 3 were emaciated when examined post-mortem, as were the carcasses of 2 other mortalities. This level of emaciation, combined with bacterial septicemia observed in some tissues from necropsied foxes, suggests the presence of bacterial infection in some Santa Rosa foxes.

**Table 18. Island foxes released to the wild, Santa Rosa Island, 2006.**

| PitTag | ID   | Sex | Age | Born <sup>1</sup> | Released   | Release Site     | Type <sup>2</sup> | Fate          |
|--------|------|-----|-----|-------------------|------------|------------------|-------------------|---------------|
| F4A18  | F137 | F   | 8   | W                 | 5/3/2006   | pens             | E                 | In wild       |
| 73D0D  | M21  | M   | 7   | W                 | 9/27/2006  | Quemada Canyon   | SP                | In wild       |
| 3512D  | F131 | F   | 8   | W                 | 9/27/2006  | Quemada Canyon   | SP                | In wild       |
| 12270  | M23  | M   | 0   | C                 | 10/2/2006  | Quemada Canyon   | Gr                | In wild       |
| D187A  | F133 | F   | 8   | W                 | 10/2/2006  | Quemada Canyon   | Gr                | d. 11/1/2006  |
| 0507B  | M25  | M   | 3   | C                 | 10/4/2006  | Verde Canyon     | Gr                | d. 11/26/2006 |
| 32219  | M24  | M   | 1   | C                 | 10/4/2006  | Verde Canyon     | Gr                | d. 11/2/2006  |
| 1612C  | F135 | F   | 7   | W                 | 10/11/2006 | Arlington Canyon | Gr                | In wild       |
| 9230A  | M27  | M   | 2   | C                 | 10/11/2006 | Arlington Canyon | Gr                | d. 11/26/2006 |
| 72269  | M26  | M   | 0   | C                 | 10/11/2006 | Arlington Canyon | Gr                | d. 11/11/2006 |
| 70518  | M29  | M   | 6   | C                 | 10/15/2006 | Verde Canyon     | SP                | d.11/15/2006  |
| 10030  | F136 | F   | 8   | W                 | 10/15/2006 | Verde Canyon     | SP                | In wild       |
| 3045D  | M30  | M   | 0   | C                 | 10/18/2006 | Arlington Canyon | Fa                | In wild       |
| B2D61  | M31  | M   | 0   | C                 | 10/18/2006 | Arlington Canyon | Fa                | In wild       |

<sup>1</sup>W = wild, C = captive

<sup>2</sup>Gr = group, Fa = family group, FP = failed pair, SP = successful pair, E = escape from captivity

## Monitoring

For methods, see description under monitoring methods for San Miguel (p. 17)

### Mortality Monitoring

Throughout 2006 we maintained a sample of 20-35 radiocollared foxes on Santa Rosa, and by the end of 2006 there were 34 radiocollared foxes on the island. Collared foxes included those released from captivity and some wild-born foxes. Annual Kaplan-Meier survival for Santa Rosa Island foxes in 2006 was 49% (80% CI = 41-57%). An annual survival rate of 80% is required for a stable or increasing fox population (Roemer et al 2001b). In 2006, annual survival on Santa Rosa, which has always been lower than that on San Miguel, dipped below 50% for the first time since early 2005 (Fig. 8). The primary mortality sources were golden eagle predation and an unknown bacterial pathogen.

A total of 20 radiocollared foxes died on Santa Rosa in 2006 (Table 19). Five foxes which died early in 2006 were determined to have died from golden eagle predation. Although golden eagles

did not breed on Santa Rosa in 2006 (IWS 2006), marking the first time since 1997 that they did not do so (Collins and Latta 2006), eagle presence was still sufficient to make golden eagle predation a significant mortality factor for island foxes. The 5 predation-caused mortalities occurred in February and March, which is also when eagle survey crews recorded 3 sightings of a subadult golden eagle on Santa Rosa Island (IWS 2006). Unlike in other years, the eagle predation-caused mortalities were not clustered near the Trap Canyon eagle nest location (Fig. 9). Nine other mortalities occurred in October-November, but were not due to predation; the carcasses were found intact. Five of these carcasses were in sufficient condition to investigate other causes of mortality, and all 5 of these intact carcasses were determined to be emaciated, though emaciation may not have been the direct cause of death for all 5 foxes. The carcasses with emaciation were not spatially associated (Fig. 9). Results from histological testing revealed bacterial septicemia. Four foxes with septicemia had primary sites of infection including 2 foxes with cholecystitis and 2 foxes with infected wounds. The other emaciated fox was entrapped in a pipe. To rule out the presence of a primary bacterial pathogen such as *Salmonella*, *Pasteurella*, or *Yersinia* in the fox population, Drs. Munson and Vickers recommended that blood and fecal cultures be conducted on wild foxes. Island staff attempted to capture foxes which may have had the bacterial infection, as indicated by results of previous blood sample testing (high white blood cell counts, high blood urea nitrogen, high globulin, or high alanine aminotransferase [ALT]). Five radiocollared foxes captured during fall monitoring had these symptoms, and island staff were able to trap 3 of them in January-February 2007. Blood and fecal cultures from these foxes were negative for any of the suspected bacteria, although cultures from one fox returned evidence of *Campylobacter*, a bacterium that can cause intestinal diseases but is not known to be a mortality cause (W. Vickers, Institute for Wildlife Studies, pers. comm.).

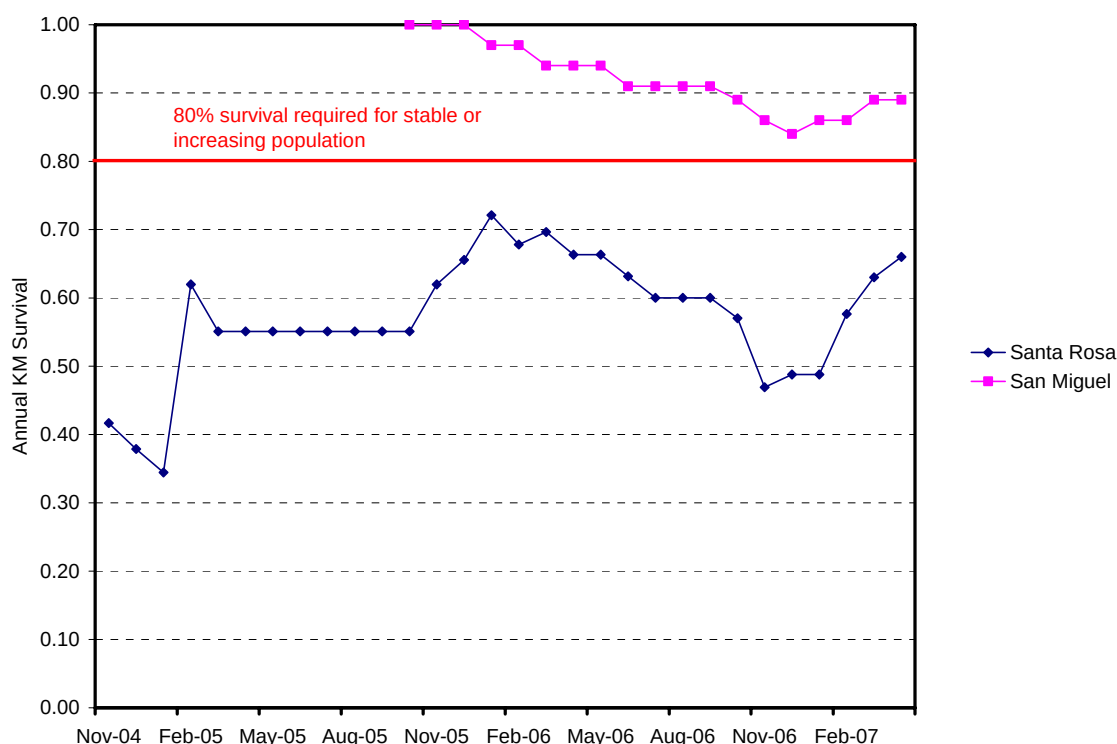


**Figure 8. Rolling annual Kaplan-Meier survival estimate for island foxes on San Miguel and Santa Rosa Islands.**

**Table 19. Island fox mortalities, Santa Rosa Island, 2006.**

| PitTag | ID   | Sex | Born    | Age | Date       | Mortality Cause and Findings                          |
|--------|------|-----|---------|-----|------------|-------------------------------------------------------|
| E1F30  | F127 | F   | Wild    | 1   | 2/1/2006   | Predation                                             |
| 53723  | M17  | M   | Captive | 4   | 2/1/2006   | Predation                                             |
| E3F0F  | F128 | F   | Captive | 4   | 2/9/2006   | Predation                                             |
| 53A3F  | F122 | F   | Wild    | 1   | 2/12/2006  | Predation                                             |
| 2571A  | F113 | F   | Captive | 4   | 3/8/2006   | Predation                                             |
| B7D38  | F120 | F   | Captive | 3   | 3/22/2006  | Intestinal intussusception                            |
| B7A6D  | M13  | M   | Captive | 2   | 4/1/2006   | Undetermined                                          |
| 63F2A  | F123 | F   | Captive | 4   | 4/1/2006   | Undetermined                                          |
| 25C14  | M10  | M   | Captive | 1   | 6/20/2006  | Undetermined due to autolysis                         |
| 84F28  | M11  | M   | Captive | 6   | 7/19/2006  | Undetermined due to mummification; not predation      |
| 0654E  | M18  | M   | Captive | 6   | 9/19/2006  | Emaciation and wound infection                        |
| 60B1D  | F126 | F   | Captive | 5   | 10/8/2006  | Undetermined due to autolysis; not predation          |
| 95906  | F103 | F   | Captive | 4   | 10/21/2006 | Undetermined; not predation                           |
| D187A  | F133 | F   | Wild    | 8   | 11/1/2006  | Undetermined due to autolysis; not predation          |
| 32219  | M24  | M   | Captive | 1   | 11/2/2006  | Cholecystitis with septicemia                         |
| 72269  | M26  | M   | Captive | 0   | 11/11/2006 | Undetermined due to autolysis; not predation          |
| 70518  | M29  | M   | Captive | 6   | 11/15/2006 | Undetermined due to autolysis; not predation          |
| D4C78  | M08  | M   | Captive | 3   | 11/15/2006 | Septicemia secondary to cellulitis or colon abscesses |
| 0507B  | M25  | M   | Captive | 3   | 11/26/2006 | Cholecystitis with septicemia                         |
| 9230A  | M27  | M   | Captive | 2   | 11/26/2006 | Entrapment                                            |

Although the emaciation raised concern about the nutritional status of wild foxes, these concerns were allayed by the good weight values and body condition values of foxes captured in December and January (Fig. 10).

To investigate the possibility that some of the mortalities resulted from ingestion of lead ammunition used in the fall hunt for deer and elk, Dr. Linda Munson of University of California, Davis, ran liver toxicological screens on 3 carcasses from Santa Rosa and one from San Miguel. All foxes showed lead concentrations of < 1 ppm, indicating that lead poisoning from ungulate carcasses was not a mortality cause.

Necropsy on the foxes that were emaciated revealed a number of other factors that contributed to mortality. Male M24 was hand-captured on November 1 near the foxpital in a weakened condition, with a body weight of 1.4 kg. The fox had been released on October 4 at a weight of 2.45 kg. The fox did not survive the night. Subsequent pathology evaluations determined that, in addition to emaciation, the fox had an infection of the gall bladder (cholecystitis) with secondary severe icterus (jaundice) and septicemia.

Male M18 was emaciated and had a deep laceration in his thigh that extended deep into the musculature, exposing the sciatic nerve. The surrounding skin was necrotic. The wound likely resulted from an aggressive encounter with another fox. Two established wild pairs had recently moved into the Trancion Canyon area frequented by M18 at the time of his death.

Male M27, released to the wild on 11 October 2006, was found dead on 26 November, apparently stuck in a PVC culvert pipe at a ranch residence in the Becher's Bay area. Although emaciated (he weighed 1.4 kg, compared to his release weight of 2.6 kg), there was a normal amount of feces in the colon, suggesting he had eaten recently. He also had evidence of acute septicemia, although the site of entry for infection was not determined.

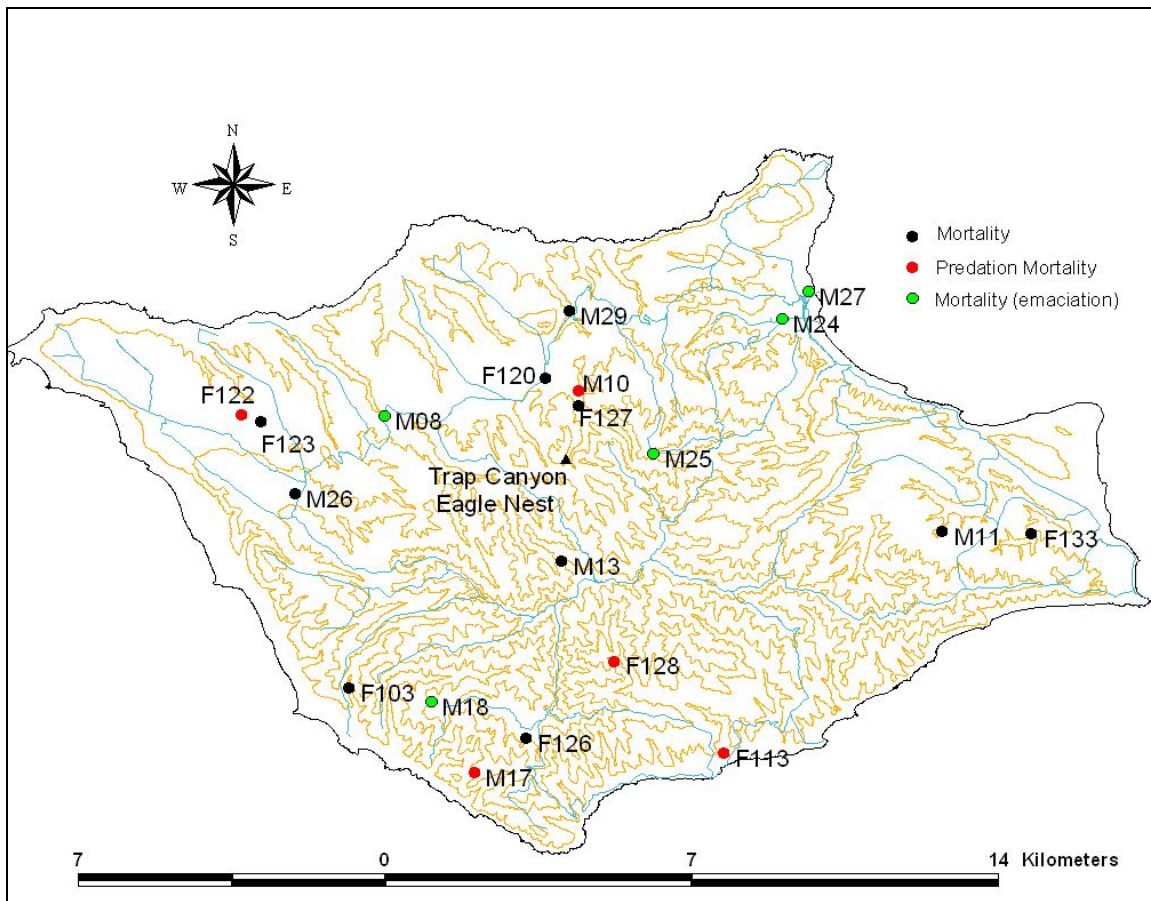


**Figure 9. Locations of island fox mortalities, Santa Rosa Island, 2006.**

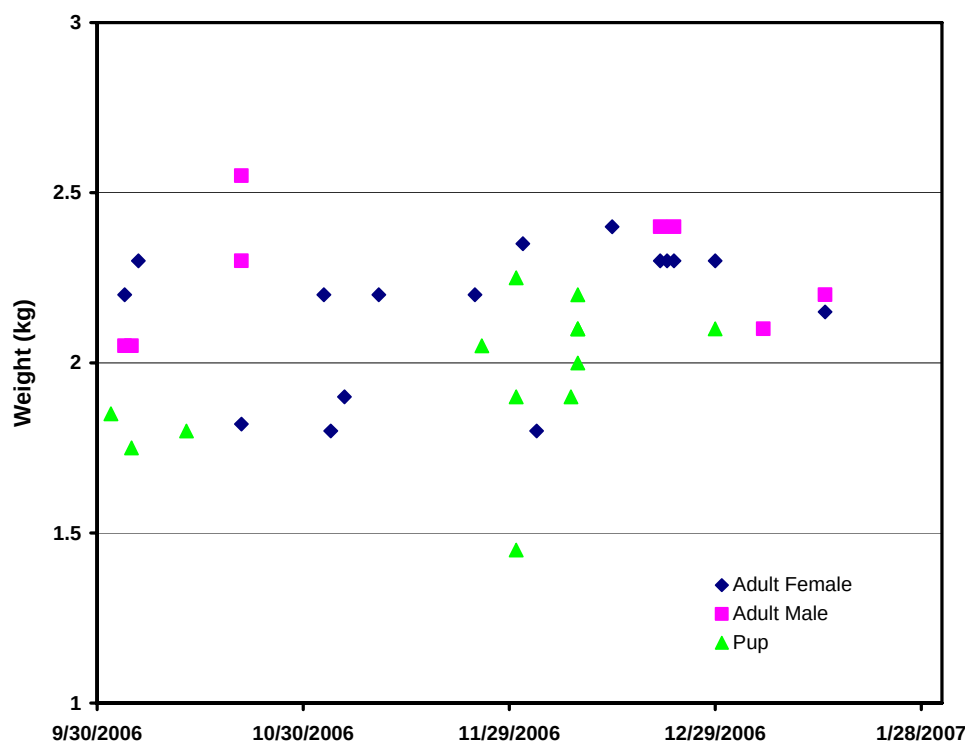


**Figure 10. Weights of trapped island foxes, Santa Rosa Island, October 2006 - January 2007.**

Male M25, another recent releasee that also died on 26 November, was emaciated, but like M27 had a normal amount of feces in his colon. He had an infection of the gall bladder (cholecystitis) with secondary icterus (jaundice) and septicemia, similar to M24.

Male M08, who died 15 November, had been released to the wild in 2004 and sired two wild litters. Necropsy determined his carcass to be markedly emaciated, though his stomach was full of food presumably from a feeding station near which he was found. He had bacterial septicemia that arose either from the infected *Spirocerca* lesions in his colon or from his infected wounds (cellulitis).

## Population Monitoring

From May through August 2006 we deployed remote cameras near likely densites to monitor reproductive success (number of pups weaned) for 10 pairs on Santa Rosa Island (Table 20). A total of 13 pups were observed in 4 of the 10 territories. Fall trapping confirmed that 14 wild-born pups (10 males and 4 females) had survived through the summer and into the fall, and 10 of those pups were subsequently radiocollared (Table 21). Reproductive success for wild Santa Rosa females was 1.4 pups/female (14 pups/10 females), less than that on San Miguel (2.1 pups/female).

Trapping was conducted on 13 transects from late September 2006 through January 2007 (Fig. 11). A total of 38 individual foxes were captured on the transects, and trap efficiency was 5.2% for individuals and 12.4% for fox captures (Table 14). Both of these values were 1/3 of those on San Miguel. During the same period, 310 individual skunks (marked with passive integrated transponder tags) were captured. Relative abundance of skunks was over 8X that of foxes. The 51.5% trap efficiency for skunks was twice that of the previous year (25.5%: 67 skunk captures in 263 trapnights [T. Coonan, National Park Service, unpubl. data]).

The minimum number of Santa Rosa Island foxes known to be alive (MNKA) at the end of 2006 was the sum of the number of individuals caught during fall trapping (38) and the number of radiocollared individuals not caught during trapping but known to be alive (2). At the end of 2006, the MNKA was 40 on Santa Rosa, half of the MNKA for San Miguel (80).

**Table 20. Number of pups observed via direct observation or remote camera for 10 island fox pairs, Santa Rosa Island, 2006.**

| Pair# | Female | Female Born | Female Age | Male | Male Born | Male Age | Pups Observed |
|-------|--------|-------------|------------|------|-----------|----------|---------------|
| R0601 | F104   | Captive     | 3          | M08  | Captive   | 3        | 5             |
| R0602 | F118   | Wild        | 2          | M09  | Captive   | 2        | 4             |
| R0603 | F103   | Captive     | 4          | M02  | Captive   | 5        | 2             |
| R0604 | F111   | Captive     | 5          | M06  | Captive   | 4        | 0             |
| R0605 | F125   | Captive     | 3          | M12  | Captive   | 5        | 0             |
| R0606 | F107   | Captive     | 3          | M20  | Wild      | 1        | 0             |
| R0607 | F109   | Captive     | 4          | M18  | Captive   | 6        | 0             |
| R0608 | F126   | Captive     | 5          | M14  | Wild      | 1        | 0             |
| R0609 | F129   | Wild        | 1          | M19  | Captive   | 1        | 2             |
| R0610 | F121   | Wild        | 1          | M10  | Captive   | 1        | 0             |

**Table 21. Island foxes born in the wild on Santa Rosa Island, 2006 and subsequently caught during fall trapping efforts.**

| PitTag | ID   | Sex | Captured   |
|--------|------|-----|------------|
| 7634C  |      | M   | 9/30/2006  |
| 72139  | M22  | M   | 10/1/2006  |
| 50E01  | F132 | F   | 10/2/2006  |
| B0D62  | F134 | F   | 10/5/2006  |
| 2543F  | M28  | M   | 10/13/2006 |
| E0472  |      | F   | 10/13/2006 |
| 51511  | M32  | M   | 11/2/2006  |
| 23450  | F138 | F   | 11/11/2006 |
| E1D7D  |      | M   | 11/12/2006 |
| D516D  | M33  | M   | 11/25/2006 |
| 21022  |      | M   | 11/30/2006 |
| A1242  | M34  | M   | 11/30/2006 |
| D353A  | M35  | M   | 12/9/2006  |
| 31311  | M36  | M   | 12/29/2006 |

## ***Future Plans***

The results of mortality and population monitoring show wild island foxes to be in a tenuous position on Santa Rosa Island. The wild population is half that of San Miguel, even though releases started a year earlier on Santa Rosa. The population suffered significant mortality in 2006, when 20 radiocollared foxes died. Annual survival was 50%, considerably less than survival on San Miguel (84%). Reproduction in the wild on Santa Rosa (14 pups, 1.4 pups/female) was less than half that on San Miguel (32 pups, 2.1 pups/female). The San Miguel population is on an apparent trajectory toward recovery, with high wild survival and high wild recruitment far outstripping that in captivity, enough to support closing the captive facility. This is not the case for Santa Rosa. Until wild survival and recruitment improve on Santa Rosa, captive breeding and release will be an important tool for increasing the small wild population, and so will continue in the near future.

Up to 20 island foxes will be released on Santa Rosa in fall 2007, provided that eagle predation does not force implementation of contingency measures, and that pup production in spring 2007 is adequate. The annual activities authorized under this permit will continue. Pups born in 2007 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 2007.



*Female F11 and male M06, Torrey pines,  
Santa Rosa Island, 2006*

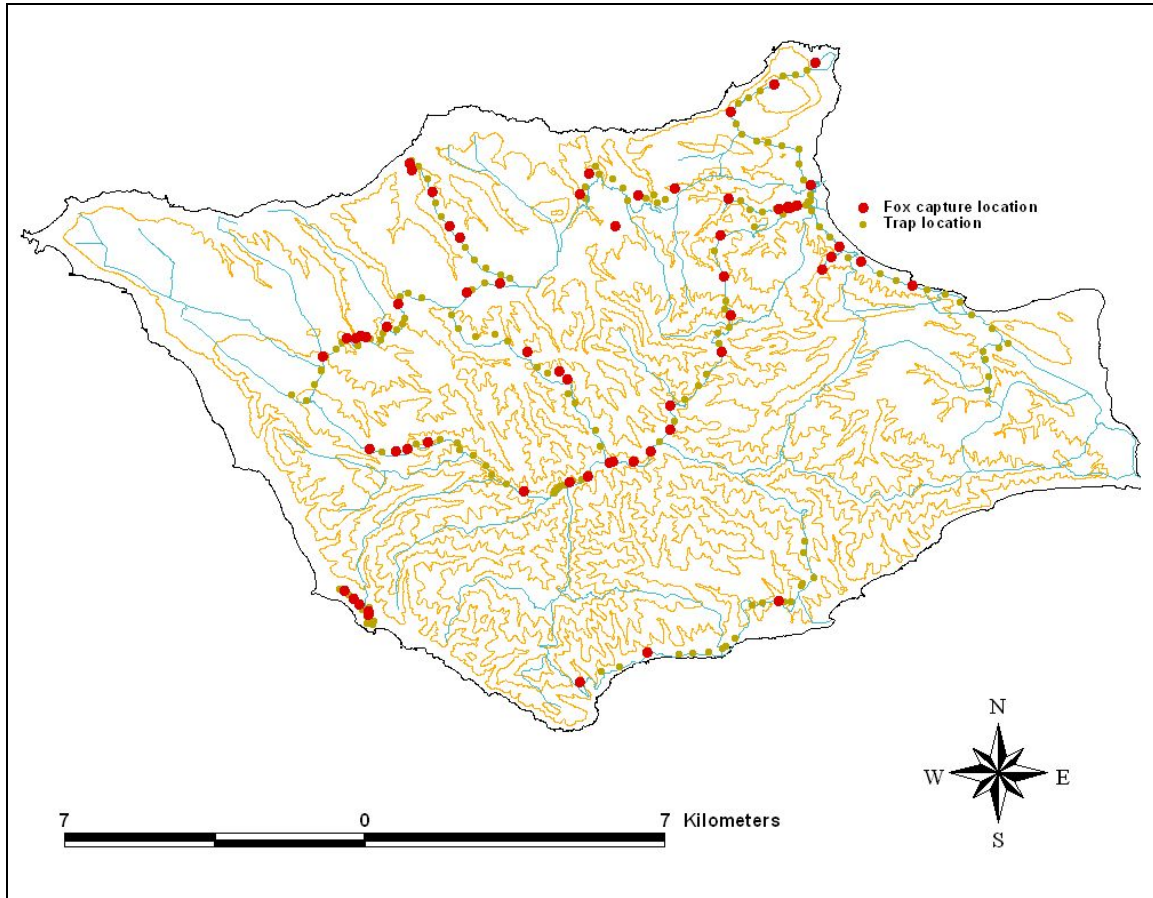


**Figure 11. Locations of foxes trapped on transects September 2006 - January 2007, Santa Rosa Island.**

## **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 Golden Eagles***

In 2006 The Nature Conservancy contracted with the Institute for Wildlife Studies (IWS) for survey and live-capture of golden eagles on the northern Channel Islands, and also organized a helicopter net-gun operation in June 2006 that succeeded in capturing two adult nesting eagles on Santa Cruz Island (Institute for Wildlife Studies 2006). The two adult golden eagles were a

breeding pair which had evaded ground-capture attempts at the nest-site. Prior to their capture, the golden eagle pair, which had nested in Laguna Canyon, was responsible for the deaths of approximately a dozen island foxes, including several radiocollared animals. After capture, the lone eaglet in the nest was removed by hand and released from a hacking tower near San Diego. The adults were transported to northeastern California and released.

The removal of the three eagles in June 2006 brought the number of eagles removed since 1999 to 44, including 31 adults. As of May 2007 only one eagle was thought to remain. That eagle was apparently responsible for the deaths of 12 released island foxes which died between November 2006 and May 2007 on the west end of Santa Cruz Island. Two helicopter net-gun operations in March and April 2007 failed to observe the bird.

### ***Removal of Feral Pigs from Santa Cruz Island***

Removal of feral pigs from Santa Cruz Island was completed by 2007, by which time over 6,000 pigs had been removed by ProHunt, Inc., under contract to The Nature Conservancy (S. Morrison, The Nature Conservancy, unpublished data). As of May 2007 the program was in the certification phase, during which a separate contractor (Landcare Research) is ensuring, through comprehensive monitoring, that the island is truly pig-free.

### ***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.

The goal of the study was 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 were expected to 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 two pairs of bald eagles bred successfully on Santa Cruz Island. One pair comprised a 5-yr old male and 4-yr old female, both of Santa Catalina Island origin. A second pair comprised a 5-yr old male from Catalina and a 4-yr old female from Santa Cruz. Both pairs laid an egg in early March, hatched a chick in mid-April, and fledged a chick in late July.

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 were scheduled to be tested for DDT and PCB, as will samples from eagle prey items (marine fishes, seabirds, and pinniped carcasses).

### ***Removal of Ungulates from Santa Rosa Island***

Golden eagle breeding on the northern Channel Islands has been supported by an alien prey base, feral pigs on Santa Cruz Island and non-native mule deer and elk on Santa Rosa Island. Deer carcasses from the annual fall hunt provided resources for wintering golden eagles, and deer fawn prey remains found in Santa Rosa golden eagle nests indicate deer is the primary prey resource allowing successful golden eagle breeding on that island (Collins and Latta 2006). With pigs gone from Santa Cruz Island, deer and elk on Santa Rosa remain the largest remaining prey base for golden eagles. Over 400 deer and over 700 elk inhabit Santa Rosa, with their numbers increasing in the spring/summer via reproduction and decreasing to allowed maxima (425 deer and 740 elk) by the end of the calendar year. The deer and elk are private property owned by Vail and Vickers, Inc., formerly the owners of the island until it was bought by the NPS in 2006. The NPS currently authorizes Vail and Vickers to operate a commercial hunt for the deer and elk. The ungulates are scheduled to be removed by Vail and Vickers in 2011, according to a settlement negotiated in 1998 among National Parks and Conservation Association, NPS, and Vail and Vickers. Until the ungulates are removed or reduced to a handful of individuals, they could potentially support breeding golden eagles, which would also prey on island foxes. The current Santa Rosa fox population is small (50 individuals), suffers from high mortality, and is vulnerable to catastrophic predation. Since 2003 12 of 56 foxes released to the wild on Santa Rosa died from eagle predation, which also had the effect of hampering fox reproduction by removing members of successful pairs. The ungulate populations on Santa Rosa Island constitute a potential threat to fox recovery on that island.

### **Budget**

A total of approximately \$810,304 was spent by the NPS on island fox recovery on the northern Channel Islands in fiscal year 2006 (Table 22), and a variety of funding sources contributed to the effort. Monies from the base increase for fox recovery comprised the largest single NPS funding source, at \$472,966.

Captive breeding costs totaled approximately \$580,937, 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 golden eagle removal in 2006 and the costs of radiotelemetry monitoring of wild Santa Cruz Island foxes. From July 2006 – June 2007, TNC spent over \$400,000 on captive breeding and wild fox monitoring, and golden eagle removal (S. Morrison, TNC, pers. comm.).

**Table 22. Expenditures by NPS, by funding source, for island fox recovery actions in fiscal year 2006 (October 1, 2005 through September 30, 2006).**

|                | Parkbase<br>8125-<br>3000-NZI | Fecal<br>Genotyp.<br>8120-0601-<br>NNE | Fox<br>Donation<br>8120-<br>7150-600 | NPF<br>Settlement<br>8120-7175-<br>600 | Hoegh<br>Settlement<br>8120-8504-<br>600 | Fox Base<br>8125-<br>1000-NZE | Total   |
|----------------|-------------------------------|----------------------------------------|--------------------------------------|----------------------------------------|------------------------------------------|-------------------------------|---------|
| Program Coord. | 98,368                        |                                        |                                      |                                        |                                          |                               | 98,368  |
| Annual Meeting |                               |                                        | 6,707                                | 6,627                                  |                                          | 83                            | 13,417  |
| Eagle Removal  |                               | 37,582                                 |                                      | 80,000                                 |                                          |                               | 117,582 |
| Fox Food       |                               |                                        | 128                                  | 8,668                                  | 369                                      | 18,491                        | 27,655  |
| Personnel      |                               |                                        | 1,416                                | 29,007                                 | 1,415                                    | 362,907                       | 394,745 |
| Supplies       |                               |                                        | 16,218                               | 32,551                                 | 84                                       | 16,467                        | 65,320  |
| Transportation |                               |                                        | 175                                  |                                        |                                          | 50,753                        | 50,928  |
| Travel         |                               |                                        | 61                                   | 6,331                                  |                                          | 21,887                        | 28,279  |
| Vet Costs      |                               |                                        |                                      | 11,631                                 |                                          | 2,379                         | 14,010  |
| Total          | 98,368                        | 37,582                                 | 24,706                               | 174,815                                | 1,867                                    | 472,966                       | 810,304 |

In 2006 the NPS continued its support of the annual fox recovery team meeting, and supported an island fox fecal genotyping study by Melissa Gray of the University of California, Los Angeles. The study is investigating whether fecal genotyping is an effective method for estimating island fox population size.

### **Future Costs**

Estimated costs to NPS for island fox recovery actions in fiscal year 2007 total approximately \$700,000 (Table 23). Personnel costs for captive breeding, reintroduction and monitoring comprise the single largest expenditure, at just under \$400,000. Available funding sources include the parkbase increase for island fox recovery (\$477,000), other parkbase monies, and the remainder of settlement monies from environmental contaminant cases. The park's island fox budget is declining, due to a general decrease in the number of funding sources available for fox recovery work. In 2007 NPS will not be able to support any golden eagle removal efforts, all of which will be funded by The Nature Conservancy. The number of island-based fox program staff will be decreased; as vacancies occur due to staff leaving, they will not be filled. Park financial support of the annual fox meeting will be half what it has been in the past.

**Table 23. Estimated cost to NPS of island fox recovery actions in fiscal year 2007.**

| Category            | Cost    |
|---------------------|---------|
| Program coordinator | 102,169 |
| Personnel           | 398,869 |
| Travel              | 22,987  |
| Fox food            | 25,000  |
| Transportation      | 54,473  |
| Supplies            | 30,000  |
| Veterinary care     | 15,000  |
| Annual fox meeting  | 8,000   |
| Total               | 656,498 |

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## Appendix A      Foxes Currently in Captivity

**Table 24. Island foxes currently in captivity, San Miguel Island, 2007.**

| Pen | PitTag | Studbook<br>Number | Sex | Age | Years<br>Paired |
|-----|--------|--------------------|-----|-----|-----------------|
| M01 | 87F53  | 133                | M   | 5   |                 |
| M01 | 85764  | 135                | F   | 5   | 5               |
| M02 | E4B2D  | 237                | M   | 3   |                 |
| M02 | C5D00  | 231                | F   | 3   | 2               |
| M03 | C4A16  | 82                 | M   | 6   |                 |
| M03 | 71071  | 46                 | F   | 8   | 6               |
| M04 | E666D  | 167                | M   | 4   |                 |
| M04 | B0B25  | 48                 | F   | 8   | 3               |
| M08 | 92804  | 12                 | F   | 15  |                 |
| M08 | 7534A  | 14                 | F   | 14  |                 |
| M09 | C311C  | 165                | M   | 4   |                 |
| M09 | 2033F  | 270                | F   | 2   | 2               |
| M10 | 07541  | 266                | M   | 2   |                 |
| M10 | 3167E  | 271                | F   | 2   | 1               |
| M11 | 47B06  | 63                 | M   | 7   |                 |
| M11 | E2677  | 36                 | F   | 9   | 7               |

**Table 25. Island foxes currently in captivity, Santa Rosa Island, 2007.**

| Pen | PitTag | Studbook<br>Number | Sex | Age | Years<br>Paired |
|-----|--------|--------------------|-----|-----|-----------------|
| R01 | 80C3F  | 222                | M   | 3   |                 |
| R01 | 25D54  | 149                | F   | 5   | 3               |
| R02 | 7235F  | 219                | M   | 3   |                 |
| R02 | A5E60  | 265                | F   | 3   | 2               |
| R03 | 47E09  | 178                | M   | 4   |                 |
| R03 | A180A  | 53                 | F   | 7   | 1               |
| R04 | 64A43  | 304                | M   | 2   |                 |
| R04 | D590E  | 298                | F   | 2   | 2               |
| R05 | 1271E  | 144                | M   | 5   |                 |
| R05 | 96C2E  | 74                 | F   | 6   | 1               |
| R06 | 01262  | 339                | M   | 1   |                 |
| R06 | C4A1F  | 342                | F   | 1   | 1               |
| R07 | F0223  | 28                 | M   | 9   |                 |
| R07 | 07061  | 225                | F   | 9   | 1               |
| R08 | 85420  | 224                | M   | 3   |                 |
| R08 | 2410E  | 54                 | F   | 7   | 2               |
| R09 | E5066  | 343                | M   | 1   |                 |
| R09 | E485E  | 299                | F   | 2   | 1               |
| R10 | B067E  | 24                 | M   | 9   |                 |
| R10 | 47304  | 145                | F   | 5   | 3               |
| R11 | 8024B  | 348                | M   | 1   |                 |
| R11 | 90B2D  | 340                | F   | 1   | 1               |
| R12 | C4F63  | 177                | M   | 4   |                 |
| R12 | A3B6D  | 223                | F   | 3   | 1               |
| R21 | 97541  | 305                | M   | 2   |                 |
| R21 | 31049  | 218                | F   | 3   | 2               |
| R22 | B6255  | 302                | M   | 2   |                 |
| R22 | A7954  | 170                | F   | 4   | 2               |

\*died 03/28/2007 due to reaction to lidocaine administered during surgery on back wound

## Appendix B Injuries and Other Health Problems in Captive Island Foxes, 2006

**Table 26. Injuries and other health problems in captive San Miguel Island foxes, 2006.**

| Date     | ID    | Sex | Pen | Injury                                                                                | Treatment                                                                                     |
|----------|-------|-----|-----|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 12/28/05 | B0B25 | F   | M22 | Vomit found in pen and later in foxpial pen; lethargy; minor leg wounds and ear wound | Monitored vomiting with meds; released into pen on 1/21/2006                                  |
| 1/3/06   | 55249 | F   | M07 | Ear and leg wounds from mate aggression                                               | Wound cleaning; antibiotics; staples applied to pinna; released to pen 1/17/06                |
| 1/21/06  | 52249 | F   | M07 | Ear wound again from mate aggression                                                  | Wound cleaning and antibiotics; released alone in new pen M20 on 1/31/06                      |
| 1/31/06  | 85D02 | M   | M21 | Minor wound to right foreleg                                                          | Wound cleaning and antibiotics; released to pen on 2/16/06                                    |
| 3/21/06  | C311C | M   | M09 | Edema in head due to tight collar applied during reproductive study                   | Given anti-inflammatory steroid; new looser collar affixed; released to pen 3/22/06           |
| 3/24/06  | F6558 | F   | M04 | Torn toenails                                                                         | Antibiotic ointment applied and antibiotics in pen for 5 days; stayed in pen during treatment |
| 4/25/06  | C311C | M   | M09 | Edema in head again due to tight reproductive study collar                            | Anti-inflammatory steroid given; collar removed for good; returned to pen 4/26/06             |
| 6/23/06  | 92C32 | F   | M03 | Infected eye due to foxtail                                                           | Flushed with saline solution; applied ointment; returned to pen 7/2/06                        |
| 7/30/06  | 2033F | F   | M09 | Rear foot wounds-possibly mate aggression (mate had healed wounds)                    | Cleaning and antibiotics; returned to pen 8/7/06                                              |
| 9/22/06  | 90C7D | F   | M21 | Laceration on rear paw and swollen toe                                                | Wound cleaning and antibiotics; returned to pen 9/27/06                                       |
| 9/24/06  | F6558 | F   | M04 | Torn ear from mate aggression                                                         | Stapled ear; antibiotics in pen for 5 days                                                    |
| 10/8/06  | F6558 | F   | M04 | Ear wound from previous incident still unhealed                                       | Soaked wound; returned to pen 10/10/06                                                        |
| 10/21/06 | B0B25 | F   | M22 | Severe wound to toe; fresh                                                            | Vet amputated toe;                                                                            |

| Date     | ID    | Sex | Pen | Injury                                                                                                                                                                 | Treatment                                                                                                                      |
|----------|-------|-----|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| 10/23/06 | 52249 | F   | M20 | wounds to ears-possibly mate aggression (mate had minor leg wounds)<br>Small avulsion to forepaw and puncture/tear wounds on digits-fighting with wild foxes thru pen? | wound cleaning and antibiotics; returned to pen 11/1/06<br>Vet stitched up wound to paw; antibiotics; returned to pen 10/29/06 |
| 11/9/06  | E381B | M   | M10 | Torn pad on hind foot-fighting with sibling                                                                                                                            | Wound cleaning and antibiotics; released to wild on 11/16/06                                                                   |
| 11/15/06 | E666D | M   | M22 | Minor hind foot injury                                                                                                                                                 | Wound cleaning and antibiotics; moved to pen M04 after treatment with mate B0B25 on 11/17/06                                   |
| 12/20/06 | B0B25 | F   | M04 | Skin avulsion on right hind foot and tears in between digit                                                                                                            | Vet pulled skin over wound and sutured it together; wound cleaning and antibiotics; returned to pen 01/18/07                   |

**Table 27. Injuries and other health problems in captive Santa Rosa Island foxes, 2006.**

| Date     | Fox ID | Sex | Pen | Injury                                                   | Treatment                                                                                                                                                          |
|----------|--------|-----|-----|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1/04/06  | D187A  | F   | R14 | Wounds on neck and hock, prolapsed rectum                | Prolapse resolved itself. Other wounds drained, cleaned and sutured by vet. Released into solitary pen on 01/18.                                                   |
| 1/14/06  | A180A  | F   | R03 | Infected back wound                                      | Clavamox for 2 weeks; returned to pen on 02/01.                                                                                                                    |
| 2/09/06  | 96C2E  | F   | R15 | Infected tail wound                                      | Separated again on 3/19. Surgical removal of dead infected portion of tail. Butorphenol for pain relief, Clavamox for 10 days.                                     |
| 2/19/06  | 1612C  | F   | R19 | Wounds on ear and scalp                                  | Vet drained abscess, sutured wounds. Drain tube, Clavamox for 10 days. Returned to pen 03/02; separated from male 1271E.                                           |
| 3/16/06  | 37E00  | M   | R20 | Keratoconjunctivitis (KCS, or dry eye syndrome)          | Daily flush with saline solution and treatment with BNP. Transferred to Santa Barbara Zoo 6/13/06 for daily treatment. Dewormed with Doramectin prior to transfer. |
| 3/20/06  | 07061  | F   | R18 | Wounds due to aggression                                 | Pair separated, Amoxicillin for 10 days.                                                                                                                           |
| 4/24/06  | F4A18  | F   | R05 | Mammary gland inflammation, mastitis                     | Baytril for 2 weeks, lactated Ringer's to flush out system. Escaped from foxpital 5/02/06.                                                                         |
| 6/5/06   | 8024B  | M   | R08 | Pup with Grade 5 heart murmur, underweight               | Antibiotic, Cefa drops                                                                                                                                             |
| 6/5/06   | E485E  | F   | R09 | Wounds on ear and chin                                   | Antibiotics                                                                                                                                                        |
| 6/5/06   | 31049  | F   | R21 | Swelling of mammary glands                               | Antibiotics                                                                                                                                                        |
| 9/11/06  | 47E09  | M   | R12 | Bite wound on ear                                        | Wound stapled, Clavamox for 10 days                                                                                                                                |
| 9/21/06  | B067E  | M   | R10 | Tail tip necrotic, bone exposed                          | Vet amputated 3 caudal vertebrae, sutures, clavamox, Butorphanol, lactated Ringer's, vitamin B                                                                     |
| 10/27/06 | F0223  | M   | R05 | Allergic reaction to hair dye used in reproductive study | Diphenhydramine till normal                                                                                                                                        |

| <b>Date</b> | <b>Fox ID</b> | <b>Sex</b> | <b>Pen</b> | <b>Injury</b>          | <b>Treatment</b>                                           |
|-------------|---------------|------------|------------|------------------------|------------------------------------------------------------|
| 10/27/06    | 47E09         | M          | R12        | Laceration on ear      | Wound sutured, Baytril for 7 days                          |
| 11/05/06    | A5E60         | F          | R02        | Laceration on head     | Clavamox, wound cleaned with Chlorhexadine, sutured by vet |
| 12/02/06    | A180A         | F          | R03        | Abscess on back        | Clavamox, wound cleaned with Chlorhexadine                 |
| 12/08/06    | 47e09         | M          | R12        | Wounds on ear and nose | Clavamox, Chlorhexadine,                                   |