

ISLAND FOX RECOVERY PROGRAM

SAN MIGUEL AND SANTA ROSA ISLANDS

2008 ANNUAL REPORT



National Park Service

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**National Park Service
Channel Islands National Park**

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Technical Report 09-01

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Table of Contents

Executive Summary	1
Introduction	3
Integrated Island Fox Recovery Team	5
Captive Breeding Program Retrospective	6
Recovery of San Miguel Island Foxes.....	9
Captive Breeding and Reintroduction.....	10
Monitoring Methods	10
Mortality Monitoring	13
Wild Population Monitoring	14
Vaccination of Wild Foxes.....	17
Future Plans.....	18
Recovery of Santa Rosa Island Foxes	18
Captive Breeding.....	18
Decision to Close Captive Breeding.....	21
Reintroduction.....	22
Mortality Monitoring	23
Wild Population Monitoring	25
Vaccination of Wild Foxes.....	27
Future Plans.....	27
Literature Cited.....	28
Appendix A 2008 Breeding Results for Captive Island Foxes on Santa Rosa Island.....	32
Appendix B Injuries to Captive Island Foxes, 2008	35
Appendix B Island Foxes Currently in Captivity.....	38

List of Tables

Table 1. Summary statistics for wild and captive island fox populations, San Miguel and Santa Rosa Islands, 2008.	2
Table 2. Results of island fox captive breeding on the northern Channel Islands, 1999-2008 (nd = no data).	8
Table 3. Island fox mortalities, San Miguel Island, 2008.....	14
Table 4. Adult density estimates for small grids, San Miguel Island, 2008.....	14
Table 5. Islandwide adult population estimate from grid density estimates (2006-2008) and from transect trapping (2005), San Miguel Island.....	15
Table 6. Number of foxes captured, by age and sex, on 4 San Miguel grids 2008.	15
Table 7. Adult population size and reproductive effort for island foxes on San Miguel Island, 1993-2008.	16
Table 8. Growth of captive island fox population, Santa Rosa Island.	19
Table 9. Reproductive success among captive island foxes on Santa Rosa Island, 2006-2008. ...	19
Table 10. Reproductive success of captive Santa Rosa Island foxes, 2007-2008 breeding season.	20
Table 11. Island fox pups born in captivity, Santa Rosa Island, 2008.	21
Table 12. Reproductive success for wild island foxes, Santa Rosa and San Miguel Islands, 2005-2008.	21
Table 13. Island foxes released to the wild, Santa Rosa Island, 2008.....	22
Table 14. Island fox mortalities, Santa Rosa Island, 2008-2009.	24
Table 15. Number of foxes captured, by age and on transects on Santa Rosa, 2008.	26

Table 16. Island foxes born in the wild on Santa Rosa Island, 2007 and subsequently caught during fall trapping efforts.....	27
Table 17. Injuries to captive San Miguel Island foxes, 2008.....	35
Table 18. Injuries to captive Santa Rosa Island foxes, 2008.....	35
Table 19. Island foxes in captivity, San Miguel and Santa Rosa Islands, 2009.....	38

List of Figures

Figure 1. Island fox captive breeding pens on Santa Rosa Island.....	7
Figure 2. Fox hospital, or "foxpital", built on San Miguel in 2001.....	8
Figure 3. Locations of trap sites for 4 grids, San Miguel Island, July-September 2008.....	11
Figure 4. Rolling annual Kaplan-Meier survival for island foxes, San Miguel and Santa Rosa islands.....	13
Figure 5. Number of foxes caught on each grid, San Miguel Island, 2006-2008.....	15
Figure 6. Reproductive effort (pups/female) versus adult population size, for island foxes on San Miguel Island, 1993-2008.....	16
Figure 7. Extinction risk for San Miguel Island foxes under 2006-2008 averages for adult mortality and population size.....	17
Figure 8. Location of confirmed and likely predation mortalities, Santa Rosa Island, late 2008 and early 2009.....	23
Figure 9. Locations of traps and fox capture sites on 19 transects, Santa Rosa Island, September-December 2008.....	25
Figure 10. Trap success for island foxes and island spotted skunks during annual population monitoring, San Miguel and Santa Rosa Islands.....	26



Fox released on Santa Rosa Island, November 2008

Executive Summary

In 2008 the National Park Service completed a 10-year program of captive breeding and release for the endangered island fox subspecies on San Miguel Island (*Urocyon littoralis littoralis*) and Santa Rosa Island (*Urocyon littoralis santarosae*). The San Miguel captive breeding facility had been closed in 2007, and the Santa Rosa captive facility was closed in 2008 after the final release of captive foxes in November. Island foxes had been removed from the wild for captive breeding on San Miguel in 1999, and on Santa Rosa in 2000. During the 10-year captive breeding program, 138 pups were born in captivity, and 155 foxes were released to the wild, beginning in 2003 on Santa Rosa and 2004 on San Miguel. Excellent reproduction in the wild, exceeding the per capita reproduction in captivity, was the primary reason to cease captive breeding. Also, predation by golden eagles (*Aquila chrysaetos*) had been almost completely mitigated during the 10-year time period, and wild island fox survival rose to 80-90% on both islands. The excellent survival and reproduction in the wild allowed rapid growth of the small, recovering populations, and by the end of 2008 the population estimate was 271 for San Miguel and at least 122 for Santa Rosa. The park's island fox program now enters an intensive monitoring phase to insure that recovery continues apace, and to eventually document attainment of criteria which would allow delisting of the two subspecies.

During 2008, the National Park Service continued its program of captive breeding on Santa Rosa until the facility was closed, and conducted both annual population monitoring to estimate wild population size and mortality monitoring of wild and released foxes via radiotelemetry. Summary statistics for the wild and captive populations are provided in Table 1. Reproduction in captivity in spring 2008 was mediocre, as it had been in previous years; 8 pups were born in captivity on Santa Rosa Island. Ultrasound examinations of paired females in March 2008 indicated that 8 of 12 females were pregnant, but only 4 eventually produced litters. A total of 8 pups observed on ultrasound were lost prior to pup emergence from the den. The cause of reproductive failure is unknown. No foxes died in captivity in 2008. Due to high reproduction in the wild and the declining contribution of captive foxes to fox recovery on Santa Rosa Island, NPS closed the captive breeding program on that island after releases in fall 2008, when 31 foxes were released from captivity on Santa Rosa, leaving 2 unreleasable foxes in captivity there. One unreleasable fox remained on San Miguel. By April 2009 8 of the 31 foxes released on Santa Rosa had died, and 6 of those mortalities were due to predation.

Despite the deaths of 8 released foxes, annual survival of released and wild-born foxes continued to be high on San Miguel (91%) and, for the second consecutive year since releases began in 2003, annual survival on Santa Rosa (86%) approached that on San Miguel. In addition to the released foxes, 3 other foxes died in the wild on Santa Rosa Island in 2008, and 5 on San Miguel. Seven of the 10 Santa Rosa mortalities were conclusively or possibly due to predation, though none of the San Miguel mortalities were predated. Other mortality factors included emaciation, peritonitis, amyloidosis, cardiac fibrosis, cardiac failure, and injuries possibly due to aggression.

We conducted trapping in summer-fall 2008 to monitor the 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, replace radiocollars, gauge reproduction through capture of pups, vaccinate wild foxes, and check physical conditions. A total of 75 individuals were trapped on the grids in 2008. The adult density estimates for the 4 grids, as calculated with program DENSITY, were 7.3, 3.5, 1.6, and 5.5 foxes/km². Multiplying the average adult density (4.5 foxes/km²) by the island area (38.1 km²)

yielded a population estimate of 171 adult foxes. When pups were included in density estimations, the total islandwide population was 271 foxes.

A total of 31 wild-born pups were caught on the San Miguel grids during fall trapping. Reproductive success was calculated as the number of grid pups divided by the number of adult females caught on the grids (21). The estimated reproductive success of 1.48 pups per female was similar to that of 2007.

On Santa Rosa trapping was conducted on 19 transects utilizing existing roads and trails, each transect comprising 10-40 traps. A total of 97 individuals, including 35 wild-born pups, were captured on Santa Rosa during fall trapping. Reproductive success was 1.1 pups/female (35 pups/31 females).

Table 1. Summary statistics for wild and captive island fox populations, San Miguel and Santa Rosa Islands, 2008.

	San Miguel	Santa Rosa
<i>Wild Population</i>		
Estimate (SM) or MNKA (SR)	271	122
Annual survival	91%	86%
Mortalities of radiocollared foxes	5	10
Trap efficiency		
Captures	47.1%	16.0%
Individuals	21.9%	6.0%
Recruitment		
Pups	31	36
Pups/female	1.5	1.1
<i>Captive Population</i>		
Recruitment		
Pups	--	8
Pups/female	--	0.67
Released	--	31
Left in captivity	1	2

For the Santa Rosa wild population, we calculated the minimum number known to be alive (MNKA) because transect data do not allow estimation of density. MNKA was calculated as the sum of the number of individuals caught during fall trapping (97) and the number of radiocollared individuals not caught during trapping but known to be alive (25). At the end of 2008, the MNKA was 122 for Santa Rosa.

Trap success or trap efficiency, calculated as the percentage of traps occupied by foxes, was approximately three times 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, as were most foxes captured during fall trapping efforts. All 75 San Miguel foxes caught on grids in 2008 were vaccinated against CDV and rabies. Ninety captured foxes and all 31 released foxes were vaccinated against both CDV and rabies on Santa Rosa Island. Populations on both islands are now high enough to establish a vaccinated core of foxes, and so fieldwork in 2009 will include vaccination of all foxes against rabies, but only a subset of foxes

(80-100 animals) against canine distemper virus. This will allow continued occurrence of a natural strain of CDV, and the immunity it confers, in the fox populations (there is no naturally-occurring strain of rabies).

During 2008, island foxes were held in captivity on Santa Rosa Island for the purpose of captive breeding and release to the wild. To prevent possible loss of litters due to infection such as mastitis, all females were given prophylactic doses of antibiotic early in the breeding season. Also, to prevent loss due to mate aggression, all males were removed from the breeding pens after ultrasound examination of females in March 2008. However, this did not increase pup production beyond that seen in previous years. The number of pups produced per female (0.67) was similar to that in 2007 (0.64) and less than that in the wild (1.1). Due to the declining benefit to the wild population from captive breeding, the National Park Service decided to cease captive breeding and release on Santa Rosa. Accordingly, the captive breeding facility was closed after the release of 31 foxes in fall 2008, with the only remaining captive foxes being 2 males deemed unfit for release. One of the unreleasable foxes was a captive-born male with lowered life expectancy due to a heart murmur. Another 11-year old male, one of the original wild founders brought into captivity in 2000, died on 13 March 2009 from extensive hemorrhage in the peritoneal cavity, likely due to a ruptured blood vessel. He had produced 11 pups in captivity. Additionally, the one 16-year old female that remained in captivity on San Miguel Island following that program's closure in 2007 was euthanized 18 April 2009, due to fractured vertebra and permanent paralysis from spondylosis and/or cancer. She was brought into captivity in 1999 but never produced pups.

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

Introduction

The island fox, a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. The fox exists as 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, focusing on two measures, the removal of the existing golden eagles on the islands, and captive breeding of the critically low island fox populations. 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 15 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 as known pairs or 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, mostly 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 served as members of specific technical expertise groups, from which individuals were 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 were allocated to task groups by the island fox recovery coordination group, which also received the resulting analyses from the task groups and passed on recommendations to the land management agencies, via the Service.

The integrated island fox recovery group first 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, continue work on task requests, and provide input to FWS on development of the draft island fox recovery plan (which had been tasked to the recovery coordination group). The 2007 island fox meeting marked a return to a format similar to the island fox conservation working group meetings. This included exchange of information and small workgroups addressing issues raised by the land management agencies, but not in the formal task analysis request process established by FWS. Information on the integrated island fox recovery team, and on the draft island fox recovery plan, is available from the Ventura Field Office of the U.S Fish and Wildlife Service.

Captive Breeding Program Retrospective

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. The closure of the Santa Rosa Island fox captive breeding facility in fall 2008 marked the end of a decade of island fox captive breeding. At its peak, captive breeding was conducted for all four endangered subspecies, each on its



respective island, but the duration of the captive breeding period was surprisingly short, given the long duration of captive breeding programs for other rare species. This was due to several factors. First, captive breeding worked; although island foxes had never been bred in captivity before, captive production was sufficient to move those subspecies away from the brink of extinction and build captive populations to the point that allowed annual release to the wild. Second, released foxes bred readily in the wild, as did their progeny, and wild populations increased to the point where continued augmentation from captivity was less valuable than augmentation within the wild population. The duration of captive breeding was so short that several apparent problems in captive rearing were never entirely resolved.

The goal of the park's captive breeding program was to increase wild populations of the three northern island fox subspecies to viable levels (Coonan and Rutz 2001). To support the overall objective of generating animals suitable for reintroduction to the wild, demographic modeling was used to develop a program structure that would produce a sufficient number of foxes annually to facilitate recovery of island populations to viable numbers within a reasonable timeframe, a decade (Coonan 2003). Releases to the wild could begin as soon as the target number of foxes (20 pairs) was reached in each population.

Husbandry methods for island foxes were non-existent in 1999, when the program began. Development of an appropriate diet, breeding strategy, enclosure design and veterinary program were accomplished in concert with the Santa Barbara Zoo, which had received island foxes from San Clemente Island in 1999 as part of a program to reduce predation on the endangered San Clemente loggerhead shrike (*Lanius ludovicianus clementae*). Trial and error brought quick lessons, in terms of enclosures (Fig. 1). The prodigious climbing and digging abilities of foxes required the addition of pen roofs and groundskirting, and the aggressive tendencies of foxes during the breeding season prevented adjacent pairs from being housed with common pen walls.



Figure 1. Island fox captive breeding pens on Santa Rosa Island.

With only 15 foxes left on San Miguel, and 15 on Santa Rosa, the captive program began on shaky ground in 1999/2000. Three litters were produced on San Rosa from females that were pregnant when brought into captivity that winter. On San Miguel, where only 4 potential founders were male, only one litter was produced in 2000. The populations grew at a measured pace; 2 litters were produced on San Miguel in 2001, 3 in 2002, and 5 in 2003. Of

the 4 males brought into captivity on Miguel, only 2 ever bred, and the number of eventual founders (8) was lower than that on Santa Rosa (12). These numbers were well shy of the 25-50 founders recommended to retain allelic diversity, but were close to or met the number of founders (10) required to sample 95% of a source population's heterozygosity (Ballou and Foose 1996).

Because the low numbers of potential and eventual founders represented an apparent bottleneck for the two subspecies, NPS funded molecular studies to determine relatedness among the captive individuals and to compare genetic characteristics of the captive population to that of the wild population before the decline. A bottleneck was apparent: the mean number of alleles was lower after the decline, and was lowest on San Miguel, where some alleles had disappeared (Coonan et al. 2005c). But in spite of the apparent bottleneck and relatively high relatedness among captive foxes, they showed no signs of inbreeding depression. Island foxes have experienced periodic bottlenecks over their evolutionary history (Wayne et al. 1991) and may have evolved tolerance to inbreeding. Nevertheless, stringent genetic management of the captive populations was required to avoid pairing related foxes and to maximize genetic variability and retention of founder genomes. Accordingly, the Population Management Center of the Association of Zoos and Aquariums established a studbook for the species, and analyzed the captive populations annually to develop recommendations for pairings and release (Lynch 2005a, 2005b).

Island-based captive breeding posed significant challenges, due to difficulties in transportation and limited on-island housing, a general lack of electrical power, and reduced access to services such as veterinary care. Conducting captive breeding on the mainland was not an option, and not only due to the lack of available small canid space in North American zoos. Island foxes captive-bred on the mainland and released back to the islands could possibly vector disease or parasites not previously known in island foxes. Moreover, transfer of foxes from the islands to the mainland held the possibility of introducing parasites currently found only in island foxes (such as *Spirocerca*) to mainland wildlife. For this reason a risk analysis evaluated both possible moves, and recommended an extensive process to clear island foxes of parasites before any ever came to the mainland.

Without a dedicated, on-island project veterinarian, appropriate veterinary care of captive island foxes was accomplished via contracted veterinary services, with Winston Vickers of the Institute for Wildlife Studies and with Mark Willett, and through the generosity of the Santa Barbara Zoo, which donated time by their staff veterinarian, Karl Hill. The biological technicians providing daily care for captive foxes became adept at basic veterinary procedures, guided by phone and email consultations with the veterinarians. Small veterinary hospitals, quickly dubbed “foxpitals”, were constructed on all islands (Fig. 2), though numerous veterinary procedures, even surgeries, were performed on picnic tables and in bunkhouses.



Figure 2. Fox hospital, or "foxpital", built on San Miguel in 2001.

Island fox captive breeding was successful. On the northern Channel Islands, over 250 foxes were eventually released from captivity (Table 2). On San Miguel and Santa Rosa, where foxes had been extirpated from the wild, foxes released from captivity were solely responsible for the recovery of those wild populations to over 270 foxes on San Miguel and over 120 on Santa Rosa by 2009.

Table 2. Results of island fox captive breeding on the northern Channel Islands, 1999-2008 (nd = no data).

	Brought into Captivity	Founders	Pups Produced	Released	Died in Captivity	Unreleasable
San Miguel	15	8	53	62	6	2
Santa Rosa	15	12	88	93	5	3
Santa Cruz	18	nd	85	99	nd	nd
Total			226	254		

Over the course of the 10-year captive breeding period, several problems arose, some of which were never resolved. First, reproductive success in captivity was less than that in the wild, and could largely be attributed to relatively low success by captive-born females. As successful founders “retired”, it became apparent that captive-born females were less likely to breed in captivity than were wild-born females. Breeding success of captive-born females remained low (<20%) until age 5-6, and never approached the success of whereas wild-born females had >50% success from age 1-5. Conversely, when young captive-born females were released to the wild, they reproduced at a higher rate (Coonan and Schwemm, in press). The reason for low success in captivity by captive-born females remained a mystery, but may have been due to social suppression. Spacing between pens (Fig. 1) resulted in higher density than normally occurs in the wild (6-8 adults/km²).

An occurrence of mastitis in 2005 resulted in the deaths of two captive females and the loss of several litters (Coonan and Dennis 2006). Replacement of denboxes and prophylactic treatment of pregnant females with antibiotic prevented adult deaths in subsequent years, but perinatal mortality continued: up to 1/3 of the pups seen on ultrasound failed to live. Such losses late in pregnancy were unusual for canids, and the underlying cause was never determined. It is possible that the stress of captivity compromised the immune systems of captive females, making pups more susceptible to disease. However, analysis of fecal cortisol, an indicator of stress, revealed no elevated levels in captive females (C. Asa, St. Louis Zoo, unpubl. data; granted, there is no comparative data on “normal” or typical cortisol levels in free-ranging island foxes).

A camera-based reproductive study (Sovada et al. 2007) found male aggression during the breeding season to be quite common in captive island foxes. That it resulted in serious injury to some females might be attributed to a lack of spatial options for captive females. Male aggression was also suspected to be a cause of perinatal mortality, and several males were observed on camera consuming pups (which may have died from other causes). To mitigate this possible source of female stress and pup mortality, in the latter years of the program all paired males were removed from the pens after ultrasound examination determined pregnancy. However, perinatal mortality did not decrease.

Although these problems were never resolved, the decade of breeding island foxes enabled development of effective husbandry methods for the species, and these guidelines were formally presented as the proceedings from several island fox husbandry workshops coordinated by the Santa Barbara Zoo. One advantage of continuing captive breeding, perhaps on the mainland in a research colony or for the zoo population of San Clemente island foxes, would be to further the development of husbandry methods for the species, and to resolve the issues surrounding aggression, stress, compromised immunity, and perinatal mortality. It is not inconceivable that captive breeding will be required in the future for one of the six island fox subspecies, given their naturally low population sizes and vulnerability to disease and predation. To this end the captive breeding pens will remain in place on the three northern islands until recovery is assured.



Recovery of San Miguel Island Foxes

Captive Breeding and Reintroduction

The San Miguel captive breeding program ceased in fall 2007 after the final 14 foxes were released from captivity. One unreleasable island fox (PIT tag 7534A) remained in captivity on that island until her death by euthanasia on 18 April 2009. Her health had declined to the point where euthanasia was the only option. Examination by Dr. Karl Hill of the Santa Barbara Zoo on 18 April revealed fractured vertebra and permanent paralysis, perhaps due to spondylosis or cancer. She was a 16-18 year old brought into captivity in 1999 as a potential founder, though she failed to breed in captivity. She was first caught on the original San Miguel monitoring grids in 1994, when she was identified as an age class 2 (2-3 year old) animal. When she was trapped the following year she had signs of having lactated, so she likely bred in the wild.

Monitoring Methods

We monitored island fox populations on San Miguel and Santa Rosa Island via transect trapping (Santa Rosa) and small grids (San Miguel). 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 July through September (San Miguel) and July through December (Santa Rosa), 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, 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

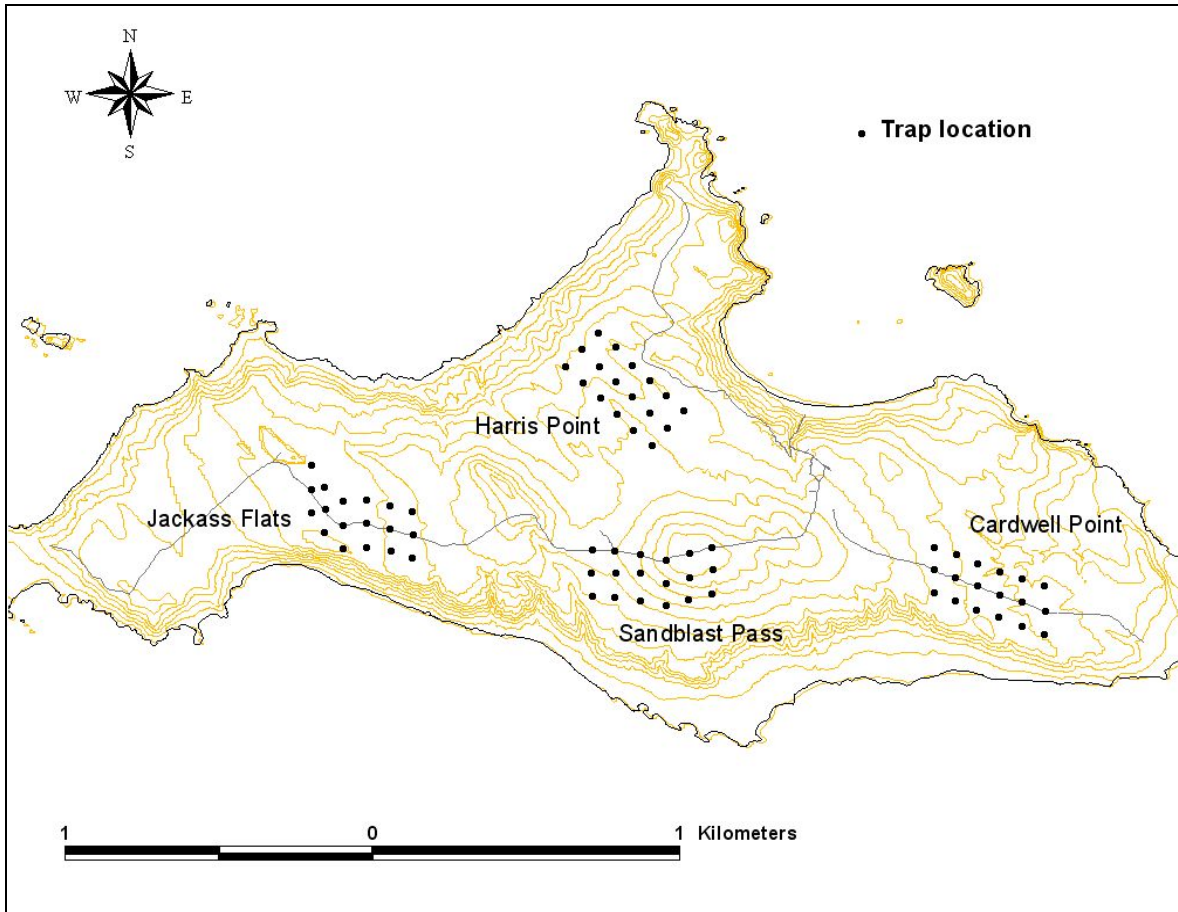


Figure 3. Locations of trap sites for 4 grids, San Miguel Island, July-September 2008.

ml from pups. A portion of the serum from each was set aside for archiving at the Institute for Wildlife Studies, and blood clots from foxes never captured before were sent to UCLA for genetic studies.

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).

To estimate density and islandwide population size, 4 small (3 x 6) grids were trapped on San Miguel. Three grids were randomly distributed along the primary east-west cross-island trail and a fourth was placed north of the central dunes and south of Hurricane Deck/Harris Point, in the only area without cultural resources (Fig. 3). For each grid, one line of traps was dispersed along the trail at 250m 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). Three of the grids were run for 5 nights, and one (Sandblast Pass) was run for 4 nights.

Capture data from each grid was analyzed via program DENSITY (Efford et al. 2004) with the maximum likelihood estimator. Average density from the 4 grids was multiplied by island size to estimate islandwide fox population size. Both the standard error for the average density and the standard error for the islandwide population estimate were calculated via the delta method (Cooch and White 2006).

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-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, they were refrigerated; otherwise they were 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.

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.).

For San Miguel, we used the islandwide population estimate and annual mortality (1 – annual survival) to determine if the recovering fox population met draft demographic recovery criteria being developed by the U.S Fish and Wildlife Service for its island fox recovery plan. Recent demographic modeling incorporated life-history characteristics of the well-studied island fox with environmental drivers and uncertainty to develop extinction probabilities for combinations of population size and annual mortality (Bakker et al. 2009). We plotted 3-year averages of adult population size and adult annual mortality to determine if those values resulted in acceptable extinction risk (5% over 50 years).

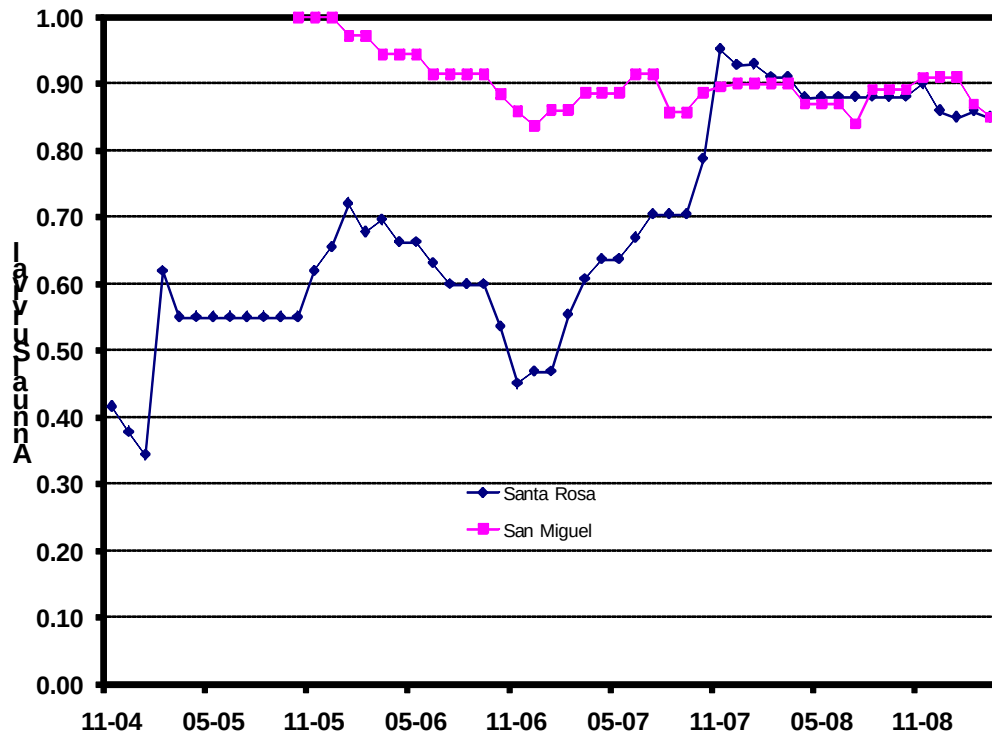


Figure 4. Rolling annual Kaplan-Meier survival for island foxes, San Miguel and Santa Rosa islands.

Mortality Monitoring

Throughout 2008 we maintained a sample of 48-57 radiocollared foxes on San Miguel, and by the end of the year there were 56 radiocollared foxes being monitored. Collared foxes included those released from captivity and some wild-born foxes. Annual Kaplan-Meier survival for San Miguel island foxes in 2008 was 91.0% (80% CI = 87-96%). Annual survival has remained above 80% since foxes were first released on San Miguel in 2004 (Fig. 4).

Five radiocollared foxes died in 2008, none from predation (Table 3). All 5 foxes were older (7-11 yrs) and 3 were wild-born founders or potential founders of the captive breeding program, eventually released from captivity. Necropsy revealed a variety of mortality causes, most considered natural. Male 57150, an 11-year old male born in the wild and brought into captivity in 1999, died from heart failure, with unusual vascular lesions in the lung that likely contributed to heart failure. He never produced pups in captivity, despite being paired with 3 different potential mates. Female E2677 was also born in the wild and brought into captivity in 1999, where she produced 14 pups from 2000-2006. Necropsy revealed her to be extremely emaciated and she had several conditions which could have contributed to the emaciation: amyloidosis, cardiac fibrosis, and arteriosclerosis. Male M237 (PIT tag 47B06) was released from captivity as a 5-year-old in July 2007 and was found dead on July 12, 2008. He was born in captivity in 2000. In captivity he was the mate of E2677. Female F323 (PIT tag F6558) was released in November 2006 as a 7-year-old and was found dead July 1, 2008. She was wild-born, one of the original founders brought into captivity in 1999, and had produced two pups in captivity.

Table 3. Island fox mortalities, San Miguel Island, 2008.

PIT Tag	ID	Sex	Born	Age	Died	Mortality Cause
57150	M226	M	Wild ¹	11	4/5/2008	Heart failure
E2677	F330	F	Wild ²	11	4/6/2008	Emaciation (amyloidosis, cardiac fibrosis, arteriosclerosis)
47B06	M237	M	Captive	9	6/27/2008	Unknown - not predation
F6558	F323	F	Wild ¹	10	7/1/2008	Not predation; emaciated, green
E270B	M202	M	Captive	7	11/23/2008	Emaciation

¹Founder released to the wild in 2006

²Founder released to the wild in 2007

Wild Population Monitoring

Grid trapping in summer/fall 2008 yielded the following measures of population health:

- Density (foxes/km²) on 4 grids
- Islandwide population estimate, extrapolated from average density
- Reproductive effort

The 4 small grids were trapped from late July through late September and a total of 75 individuals (31 pups and 44 adults) were trapped. Adult density on the 4 grids ranged from 1.6 – 7.3 foxes/km², with an average density of 4.48 foxes/km² (Table 4). The coefficient of variation for the islandwide density estimate was 0.25 (CV < 0.20 is desirable [M. Efford, Landcare Research, pers. comm.]). Multiplying the average density by the area of the island (38.1 km²) yielded a population estimate of 171 adult foxes, with 80% CI = 116-225. When pups were included in density estimates, the islandwide population estimate was 271 foxes, with 80% CI = 227-314.

The grid data from 2006 and 2007 were re-analyzed with the maximum likelihood estimator in program DENSITY to estimate adult density on the grids, and those results were extrapolated to islandwide adult population size with the delta method (Table 5). Adult density declined in 2008, though the estimate for 2007 had extremely high variance, and may be inflated. The number of foxes caught on each grid increased consistently over the 3-year period (Fig. 5). The annual rate of increase (λ , or lambda) was >2.0 in 2006 and 2007, and declined to <1.0 in 2008. Average λ was 1.75 (values of λ >1.0 indicate an increasing population).

Table 4. Adult density estimates for small grids, San Miguel Island, 2008.

Grid ¹	Date Trapped	Individ.	Capture Prob.	Density (foxes/km ²)	SE	CV ²
CHAR	7/31 – 8/4	9	0.320	3.48	2.43	0.70
CARD	8/14 – 8/18	17	0.337	7.33	2.67	0.36
SAND	8/27 – 8/31	12	0.450	1.59	1.50	0.94
JACK	9/26 – 9/29	10	0.475	5.52	1.50	0.40
average				4.48	1.12	0.25

¹CHAR = Harris Point, CARD = Cardwell Point, SAND = Sandblast Pass, JACK = Jackass Flats

²Coefficient of Variation = standard deviation/mean

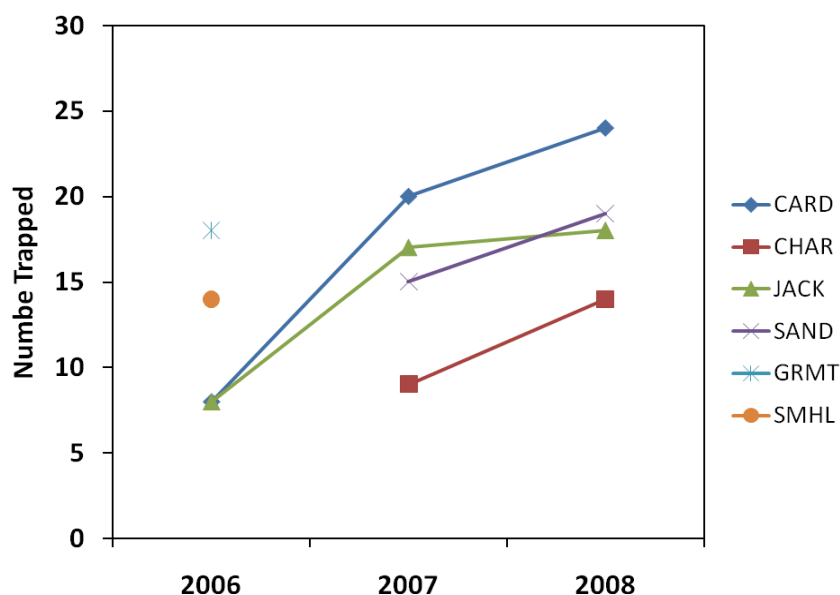


Figure 5. Number of foxes caught on each grid, San Miguel Island, 2006-2008.

Table 5. Islandwide adult population estimate from grid density estimates (2006-2008) and from transect trapping (2005), San Miguel Island.

	N	SE	Variance	80% CI	lambda
2005	40*				
2006	93	18.582	345.280	70-117	2.33
2007	188	82.941	6879.154	82-294	2.02
2008	171	42.772	1829.444	116-225	0.91

*Minimum number known to be alive from trapping and radiotelemetry

A tally of captured foxes by sex and age (Table 6) indicated a slight bias toward males in pups (18 M:13 F), as well as overall. Five of the wild-born pups were radiocollared. We measured reproductive success as the ratio of pups (31) to number of adult females (21). The estimated reproductive success of 1.48 pups/female was relatively high, compared to values from other years (including data from 1993-1999, encompassing the population decline) (Table 7). Regression of reproductive effort on adult population size showed reproductive effort declining as population increases, a density-dependent effect (Fig. 6).

Table 6. Number of foxes captured, by age and sex, on 4 San Miguel grids 2008.

	Male	Female	Total
Pups	18	13	31
Adults	23	21	44
Total	41	34	75

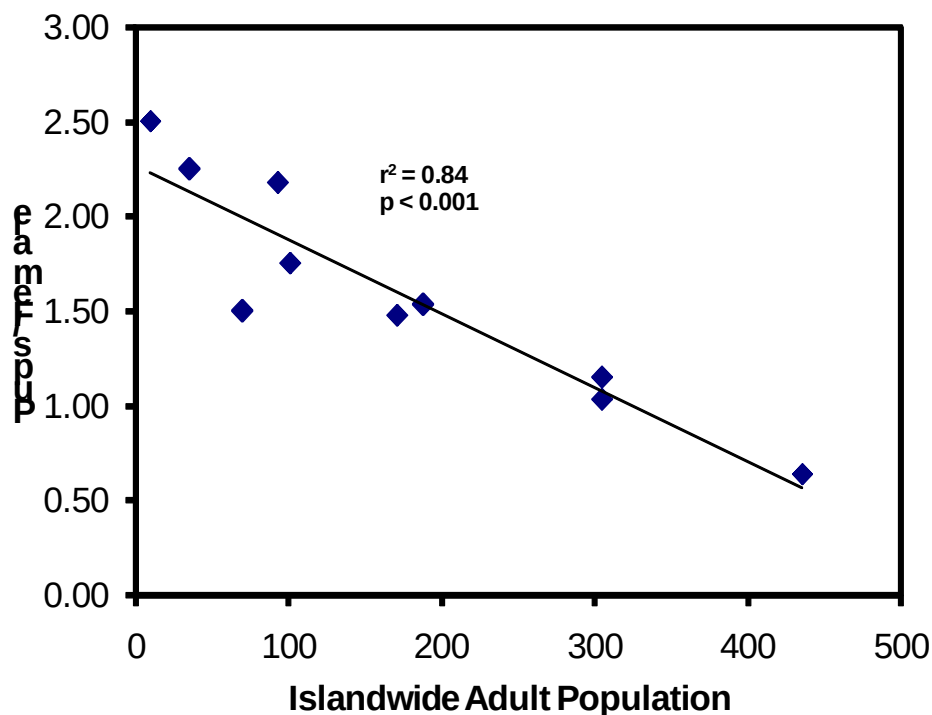


Figure 6. Reproductive effort (pups/female) versus adult population size, for island foxes on San Miguel Island, 1993-2008.

Table 7. Adult population size and reproductive effort for island foxes on San Miguel Island, 1993-2008.

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	93	2.50
2007	188	1.44
2008	171	1.48

To determine whether the San Miguel population was approaching biological recovery, we plotted 3-year averages of adult population size and adult mortality using a spreadsheet tool developed by Vicki Bakker of Arizona State University. The tool plots current values against isotopes representing various levels of extinction risk for island foxes on each island (Bakker and Doak 2009). These models are being incorporated as biological recovery criteria in the draft island fox recovery plan currently being developed by U.S. Fish and Wildlife Service. The plot (Fig. 7) shows that the 80% confidence limits for both mortality and population size fall below the 5% isoclines, which is the acceptable level of risk identified in the draft recovery plan. The

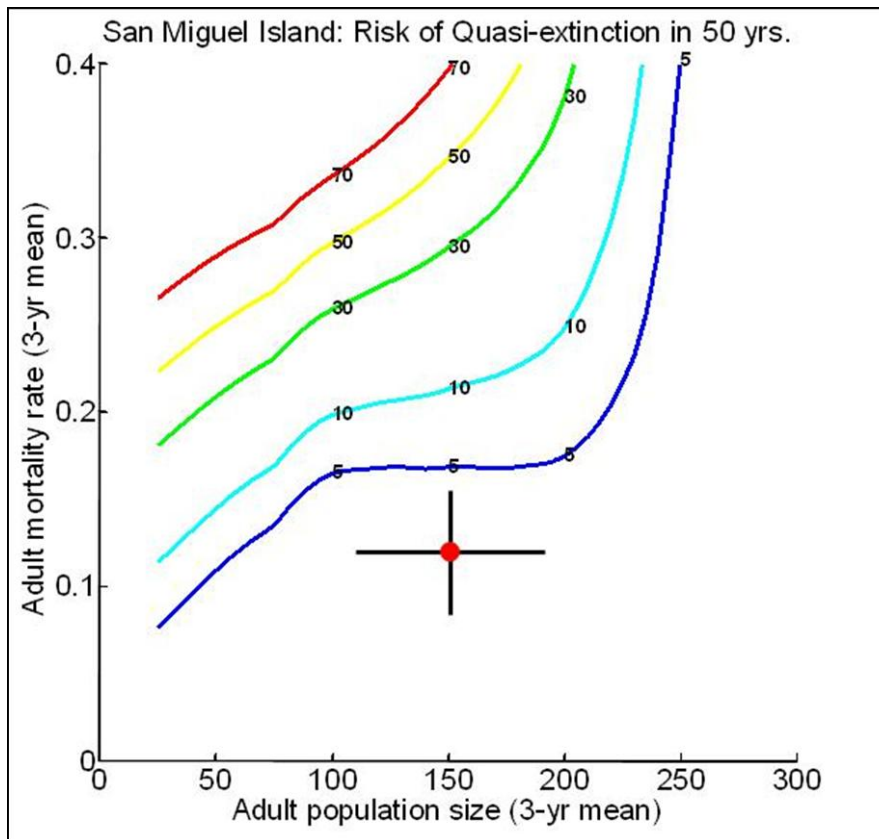


Figure 7. Extinction risk for San Miguel Island foxes under 2006-2008 averages for adult mortality and population size.

San Miguel population has reached biological recovery. Of course, the plan contains other requirements for de-listing: these levels must be reached for 5 continuous years, and there must be monitoring and actions plans in place for detecting and mitigating future episodes of predation and disease. Nonetheless, it is some comfort for the San Miguel population to have reached a measure of biological recovery 4 years after being listed, and 9 years since the population had declined to 15 individuals, at which point recovery actions began.

Vaccination of Wild Foxes

All 75 foxes trapped during grid monitoring in summer/fall 2008 were vaccinated against canine distemper virus and rabies. Up to now we have followed the guidelines for small populations (< 100), that all foxes should be vaccinated for both CDV and rabies. Now that our adult population is closer to 200 foxes, we will shift to the “vaccinated core” strategy, in which 80-100 foxes in a certain area of the island are vaccinated against CDV (see guidelines for vaccination in Fox Health Working Group report, Schwemm 2008). This allows a portion of the population to be conferred immunity via the vaccine, and a portion to be conferred immunity via the naturally occurring strain of CDV (or other morbillivirus) that is present in all island fox populations (Clifford et al. 2006). All foxes will continue to be vaccinated against rabies, since there is no naturally occurring strain of rabies in island fox populations.

Future Plans

Results from monitoring in 2008 indicate that the wild population on San Miguel is still in a phase of expansion. Survival is high, as is reproductive success, and the average rate of increase, or lambda, from 2005 to 2008 was 1.75. Although captive breeding ceased on San Miguel Island in 2007, the other annual activities authorized under this permit will continue. A portion of the wild population (40-60 foxes) will be radio-collared and regularly monitored for mortality rate and causes. Trapping will be conducted in summer/fall 2009 on the 4 small grids to estimate population size and reproductive effort. A subset (80-100) of the foxes trapped in 2009 will be vaccinated against canine distemper virus to form a “vaccinated core” which would survive future outbreaks. All captured foxes will be vaccinated against rabies. Ten to 20 juvenile (1-year old) foxes will be radiocollared but not vaccinated, to serve as a “sentinel” population to detect outbreaks of other types of pathogens.

Recovery of Santa Rosa Island Foxes

Captive Breeding

With the birth of 8 pups in spring 2008, the captive island fox population on Santa Rosa Island grew to 33 foxes, of which 31 were released to the wild (Table 8). The captive breeding facility was closed, and the only remaining foxes were two males considered unreleasable due either to age or physical condition.

Reproductive success was low in captivity on Santa Rosa in 2008, as it had been in previous years (Table 9). Four of 14 captive pairs (29%) produced litters in 2008 (Table 10). Of the 8 pups born in captivity in 2008 (Table 11), 6 were female. No new founders bred in 2008, though all potential founders (15) had by this time bred successfully, been released, or died. The number of founders remained at 12. Ten females failed to produce litters in 2008. Ultrasound testing for pregnancy in March (Clifford and Vickers 2008) showed that 8 of 14 females became pregnant, but only 4 of those 8 pregnant females produced a litter. Five females lost a total of 8 pups to neonatal mortality.

Several females were paired with multiple males during the breeding season, due to documented mate aggression which prompted us to separate some pairs prior to the time of likely mating (February) (see Appendix A). Those females were re-paired with other males. Female E485E was separated from her mate of two years, male E5099 due to injuries to her ears. The pair had been separated twice before, but were kept as a pair because ultrasound examination in 2007 showed evidence of 3 fetuses (no pups were produced). After the pair was separated in January 2008, female E485A was paired with a wild-born male, 51511, which had been brought into captivity during trapping season due to severe injuries to his head and neck. In the wild, 51511 was radiocollared male M32 and was known to be the runt of a wild-born litter. Male 51511 and female E485E did not produce a litter, nor were any pups seen on ultrasound.

Table 8. Growth of captive island fox population, Santa Rosa Island.

Year	Adults			Pups			Died	Released	Total Captive
	F	M	Total	F	M	Total			
000	8	4	12 ¹	5 ²	5 ²	10	0		22
2001	14 ³	9	23	7	3	10	1		32
2002	20	12	32	9	4	13	0		45
2003	29	16	45	6	5	11	0	7	49
2004	30	19	49	2	7	9	2	13	43 ⁴
2005	22	21	43	2	6	8	0	17	34
2006	17	17	34	2	7	9	0	13	28 ⁵
2007	14	14	28	3	6	9	1	12	24
2008	12	13	25	6	2	8	0	31	2

¹Founding population²Includes 8 pups born in captivity, and 2 pups (1 male, 1 female) born in the wild³An additional female was brought in from the wild on 05/14/2001⁴Includes 1 female pup born in the wild in spring 2004 and brought into captivity⁵Male 37E00 transferred to Santa Barbara Zoo on 6/13/2006 and female F4A18 escaped from captivity 5/3/2006

The second case of “re-pairing” was more successful, in that the female became pregnant, though no pups were ultimately produced. Female 31049 in pen R12 had been paired with male 97541 in 2005. The pair produced fetuses, but no pups, in 2006 and 2007. In the latter year two pups were born but did not survive past a few days, and the male was observed consuming one of the pups. The female was removed from the pen on 20 January, 2008 after sustaining a large wound on the back of the neck. She required 11 days to heal. Because this was the third injury caused by the male, they were not put back together. Instead male B067E (“Hef”) was paired with the female on 11 March 2008. B067E was a successful founder who sired 11 pups over the course of the captive breeding program. He had been removed from pen 10, because he tended to suffer injuries from pups, and in this case had been injured by his longtime mate, female 47304. When put in with female 31049, he also suffered injuries that ultimately caused him to be removed from this pen (R12) as well. However, the brief period he was in the pen was evidently long enough to impregnate female 31049, who showed one fetus on an ultrasound exam given 23 March. No litter was ever produced from this late pregnancy.

Observers from the reproductive study directed by Dr. Cheryl Asa of the St. Louis Zoo monitored behavior of all 14 fox pairs during breeding season (January – June) via pen cameras. Preliminary results indicate that most losses occurred in the perinatal period, either as late term abortions, stillbirths, or neonatal deaths. All females were placed on prophylactic dosage of antibiotic (Amoxicillin) prior to projected parturition date, and all males were pulled from the pens after ultrasound exams (23 March 2008) to preclude the possibility of males causing stress for pregnant females, injuring them, or killing pups. This measure did not appreciably decrease neonatal loss in 2008. Thus, it is unclear why pup loss occurred on Santa Rosa Island in 2008. Loss by late-term abortion is very unusual in canids (C. Asa, St. Louis Zoo, unpubl. data), but, in island foxes, may be indirectly related to insular evolution and inbreeding. Island foxes, particularly those on San Miguel and Santa Rosa, have high levels of inbreeding (Gray 2002). Inbreeding in domestic dogs has been associated with thyroid deficiency, which can cause abortion.

Table 9. Reproductive success among captive island foxes on Santa Rosa Island, 2006-2008.

	Litters/pairs	Pups	Per pair
2006	5/16 (31%)	9	0.56
2007	4/14 (29%)	9	0.64
2008	4/14 (29%)	8	0.57

Table 10. Reproductive success of captive Santa Rosa Island foxes, 2007-2008 breeding season.

Pen	Pit Tag	Studbook Number	Sex	Age	Born	Paired	Result	Litter Size	Pups on Ultrasound
R01	80C3F	222	M	4	Captive				
	25D54	149	F	6	Captive	10/24/2004	No Litter	0	0
R02	7235F	219	M	4	Captive				
	A5E60	265	F	4	Wild	12/11/2005	Litter	3	3
R03	C4F63	177	M	5	Captive				
	14454	366	F	1	Captive	1/20/2008	No Litter	0	3
R04	64A43	304	M	3	Captive				
	D590E	298	F	3	Captive	12/11/2005	Litter	2	2
R05	13B68	370	M	1	Captive				
	60411	369	F	1	Captive	12/26/2007	No Litter	0	0
R06	01262	339	M	2	Captive				
	C4A1F	342	F	2	Captive	11/10/2006	No Litter	0	2
R07	1271E	144	M	6	Captive				
	65F0A	365	F	1	Captive	12/26/2007	No Litter	0	0
R08	B6255	302	M	3	Captive				
	A7954	170	F	5	Captive	12/11/2005	No Litter	0	1
R09	E5066	343	M	2	Captive				
	E485E	299	F	3	Captive	11/10/2006	No Litter ¹	0	--
R09	51511	380	M	2	Wild				
	E485E	299	F	3	Captive	3/12/2008	No Litter	0	0
R10	B067E	24	M	10	Wild				
	47304	145	F	6	Captive	1/30/2004	Litter	1	1
R11	8024B	348	M	2	Captive				
	90B2D	340	F	2	Captive	11/27/2006	Litter	2	3
R12	97541	305	M	3	Captive				
	31049	218	F	4	Captive	12/11/2005	No Litter ¹	0	--
R12	B067E	24	M	10	Wild				
	31049	218	F	4	Captive	3/11/2008	No Litter	0	1

¹Male removed before possible mating (February) due to mate aggression

All captive Santa Rosa Island foxes were given annual veterinary examinations by Dr. Karl Hill, D.V.M., in September 2008. 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. Most injuries that occurred to Santa Rosa captive foxes (Appendix A) were due to mate aggression. All captive foxes were vaccinated against canine distemper virus and rabies.

One adult male fox died in captivity in 2009. Male B067E ("Hef", see above) died on 13 March 2009. Because of his age and tendency to be injured by his pups and mate, he was one of two foxes considered unreleasable and thus was not included in the large releases that closed the captive breeding program in 2008. Preliminary necropsy results indicate that his somewhat unexpected death (he had not been in decline) was due to extensive hemorrhage in the peritoneal cavity, likely from a ruptured blood vessel (L. Munson, University of California, Davis, unpubl. Data). He was a successful founder of the captive population, having produced 11 pups. The lone remaining fox in captivity is male 8024B, born in captivity in 2006 and diagnosed that year with a grade 5 heart murmur. The latter condition, considered to be life-threatening, made him unreleasable.

Table 11. Island fox pups born in captivity, Santa Rosa Island, 2008.

Pit Tag	Studbook Number	Sex	Pen	Sire	Dam
D0030	374	F	R02	7235F	A5E60
0714F	373	F	R02	7235F	A5E60
14A3D	372	M	R02	7235F	A5E60
E1207	376	F	R04	C4F63	D590E
71500	375	F	R04	C4F63	D590E
85F3C	377	M	R10	B067E	47304
C6553	379	F	R11	8024B	90B2D
1480C	378	F	R11	8024B	90B2D

Decision to Close Captive Breeding

In 2007, the San Miguel and Santa Cruz captive breeding facilities were closed, because survival in the wild was high (approximately 90%) and reproductive success in the wild was much greater than that in captivity (Coonan 2008a). At that point survival on Santa Rosa was lower, reproductive success in the wild was less than that on San Miguel, and population growth was not as high. By late 2007 annual survival on Santa Rosa had reached 90%, for the first time since releases began in 2003 (Fig. 4), and NPS began to consider the conditions under which captive breeding could cease on that island. With survival being so high in the wild, the only reason to continue captive breeding would be if the pups produced in captivity and annual releases were truly in addition to the reproduction that would occur in the wild. Conversely, if reproductive success was considerably greater in the wild, foxes currently in captivity would contribute more to population growth if they were in the wild. Accordingly, reproductive rate of captive and wild foxes in 2008 was compared (Coonan 2008b) to determine if full release, and facility closure, was justified. Annual trapping showed that at least 36 pups were born in the wild, and the number of pups trapped per female trapped was 1.1 (Table 12). In comparison, 8 pups were produced in captivity, and number of pups per captive female was 0.6 (Table 9), which was lower than in the wild, and had not improved in recent years despite changes in husbandry such as new denboxes, prophylactic antibiotics, and removing the males prior to parturition. Thus it was decided to release all captive animals that were physically fit for release, and close the Santa Rosa captive facility.

Table 12. Reproductive success for wild island foxes, Santa Rosa and San Miguel Islands, 2005-2008.

	Santa Rosa		San Miguel	
	Pups	Pups/Female	Pups	Pups/Female
2005	8	2.0	10	2.5
2006	21	2.1	37	2.5
2007	12	0.8	27	1.4
2008	36	1.1	31	1.5

Reintroduction

The final release for the Santa Rosa captive breeding facility included a total of 31 foxes (13 males, 18 females) released to the wild between 8 September and 7 November, 2008, at 9 release sites on Santa Rosa Island (Table 13). We released 6 females and 4 males which had produced or sired litters in the past. There were no founders or potential founders in the release group. The only founder left in captivity was male B067E, considered too infirm to release.

As of May, 2009, 8 of the 31 released foxes had died (Tables 13 and 14). Six of the mortalities were due to predation, and another was possible due to predation. The 6 mortalities attributed to predation and the one possible predation mortality occurred in November/December 2008, January 2009 and March 2009, some in the same area of the island (Fig. 8), suggesting that at least one golden eagle was on the island at those times (see discussion below).

Table 13. Island foxes released to the wild, Santa Rosa Island, 2008.

PIT Tag	ID	Sex	Age	Released	Site	Type ¹	Died	Litters in Captivity
31049	F155	F	4	9/8/2008	East Point	S		
97541	M55	M	3	9/8/2008	East Point	S		
47304	F102	F	6	9/8/2008	East Point	S	12/8/2008	5
0714F	F156	F	0	9/8/2008	Brockway Point	Fa		
D003E	F157	F	0	9/8/2008	Brockway Point	Fa		
01262	M56	M	2	9/21/2008	Upper Arlington	SP		
C4A1F	F159	F	2	9/21/2008	Upper Arlington	SP		2
65F0A	F158	F	1	9/21/2008	Upper Arlington	S		
E5066	M57	M	2	9/21/2008	Upper Arlington	S		
90B2B	F161	F	2	9/29/2008	Carrington Point	S	3/16/2009	2
14454	F162	F	1	9/29/2008	Carrington Reservoir	S		
13B68	M59	M	1	9/29/2008	Carrington Point	S		
1480C	F163	F	0	9/30/2008	Arlington Canyon	Fa		
C6553	F164	F	0	9/30/2008	Arlington Canyon	Fa		
E1207	F165	F	0	9/30/2008	China Camp	Fa		
71500	F166	F	0	9/30/2008	China Camp	Fa	12/3/2008	
D590E	F168	F	3	10/12/2008	Bee Canyon	SP		2
64A43	M60	M	3	10/12/2008	Bee Canyon	SP		
14A3D	M61	M	0	10/12/2008	Johnson's Lee	S	11/1/2008	
85F3C	M62	M	0	10/12/2008	Johnson's Lee	S	11/1/2008	
A5E60	F169	F	4	10/17/2008	Soledad Canyon	SP		3
7235F	M63	M	4	10/17/2008	Soledad Canyon	SP		
60411	F170	F	1	10/17/2008	Soledad Canyon	S		
25D54	F171	F	6	10/23/2008	Old Ranch Corrals	SP		2
80C3F	M64	M	4	10/23/2008	Old Ranch Corrals	SP		
C4F63	M65	M	5	10/25/2008	Old Ranch Corrals	S	1/27/2009	
51511	M32	M	2	10/28/2008	Upper Arlington	FP		
E485E	F172	F	3	10/28/2008	Upper Arlington	FP	12/13/2008	
B6255	M66	M	3	11/3/2008	Old Ranch Corrals	FP		
A7954	F110	F	5	11/3/2008	Old Ranch Corrals	FP		
1271E	M67	M	6	11/7/2008	Carrington Point	S	12/18/2008	

¹Fa = family group (siblings), FP = failed pair, SP = successful pair, S = single

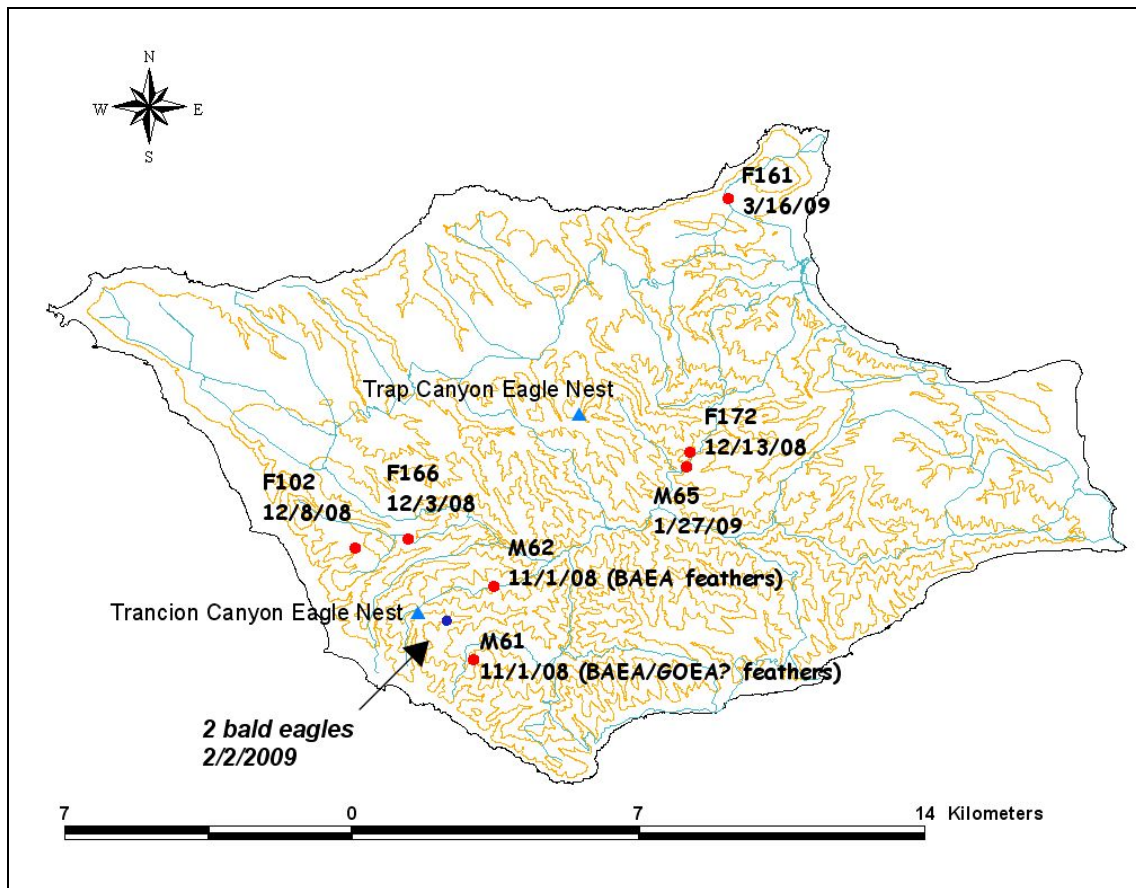


Figure 8. Location of confirmed and likely predation mortalities, Santa Rosa Island, late 2008 and early 2009.

Mortality Monitoring

Throughout 2008 we maintained a sample of 49-68 radiocollared foxes on Santa Rosa, and by the end of 2008 there were 68 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 2008 was 86.0% (80% CI = 81-91%). An annual survival rate of 80% is required for a stable or increasing fox population (Roemer et al. 2001). In 2008, annual survival on Santa Rosa, which has always been lower than that on San Miguel, remained above 80% for the second consecutive year (Fig. 4).

Nine radiocollared foxes died on Santa Rosa in 2008 (Table 14), and an additional 2 foxes died in early 2009. Ten of the 11 mortalities were positively or possibly due to predation, and both the temporal and spatial pattern of the mortalities (Fig. 8) suggest that at least one golden eagle was on the island during April, November and December 2008, and January and March 2009. Two mortalities (M65 and F161) were due to incomplete predation, in which the carcass was intact, and not consumed. Preliminary necropsy results indicate that both had puncture wounds consistent with predation (L. Munson, University of California, unpubl. data). M65 died from infection of the thorax (pleuritis) and peritoneal cavity (peritonitis) that developed from the puncture wounds. F161 died from punctures in the thorax (pneumothorax and collapsed lung). There have been very few instances of incomplete predation on island foxes. Two cases that occurred in 2007, one on San Miguel and another on Santa Rosa, were attributed to predation by

either a young, inexperienced golden eagle, or possibly by another species of raptor (Coonan 2008a). A case of incomplete predation that occurred on San Miguel in March 2009 (M221) had a pattern of puncture wounds too small to be attributed to golden eagle predation (L. Munson, University of California, Davis, unpubl. data) and occurred 2 days after the incomplete predation death of F161 on Santa Rosa.

In February ProHunt/Native Range and the Predatory Bird Research Group conducted a helicopter survey for golden eagles on Santa Rosa Island. The island was surveyed on 2 February, and no golden eagles were observed. Two bald eagles (a 3-4 year old male and 2-year old female) were observed in Trancion Canyon (B. Latta, Predatory Bird Research Group, unpubl. data).

Downy feathers were collected at the mortality sites of M61 and M62, both of whom died 1 November, 2008 in the Trancion Canyon area. Those feather samples, along with those found at a mortality site (F117) in 2005, were sent to Sandra Talbot, research geneticist for the U.S. Geological Survey at the Alaska Science Center. Analysis of a nuclear gene (beta fibrinogen) indicated the feathers found at the M62 and F117 mortality sites were from bald eagles. The sample from M61 was “contaminated”, e.g., there were feathers from >1 species present. One sample appeared to be from a bald eagle, but faint banding on another sample was consistent with that of golden eagle feathers.

Table 14. Island fox mortalities, Santa Rosa Island, 2008-2009.

Pit Tag	ID	Sex	Age	Wild/Released	Died	Mortality Cause and Findings
6717B	M49	M	1	Wild	2/1/2008	Emac., fractured ribs, heavy collar
F4A18	F137	F	10	Released	4/3/2008	Possible predation
21022	M37	M	2	Wild	4/30/2008	Predation
85F3C	M62	M	0	Released	11/1/2008	Predation
14A3D	M61	M	0	Released	11/1/2008	Predation
71500	F166	F	0	Released	12/3/2008	Predation
47304	F102	F	6	Released	12/8/2008	Unknown; tufts of fur remained
E485E	F172	F	3	Released	12/13/2008	Predation
1271E	M67	M	6	Released	12/18/2008	Aggression? Scalped?
C4F63	M65	M	5	Released	1/27/2009	Predation, incomplete; pleuritis and peritonitis from puncture wounds
90B2B	F161	F	2	Released	3/16/2009	Predation, incomplete; punctures in thorax, collapsed lung

The presence of bald eagle feathers at least one kill site implies that a bald eagle fed on the carcass, since bald eagles are well-known scavengers, but there is also a chance that bald eagles were responsible for the predation. However, the presence of golden eagle feathers at the M61 site raises the possibility that bald eagles fed on the carcass after it was killed by a golden eagle. The presence of bald eagle feathers at the sites is consistent with bald eagle sightings from the February helicopter survey, and with staff observations. Bald eagles are known to roost in the winter in a grove of oak trees on the ridgetop at the confluence of Burma Road and Rita Road, just to the northeast of the mortality sites in Trancion Canyon.

Necropsies have not yet been completed for M67, but his death might be attributed to intraspecific aggression. M67 was a 6-year old male released in the Carrington Point area in November, the very last of the foxes to be released on Santa Rosa. In mid-December staff received observations of a fox with a head wound in the Signal Road area. Staff were preparing to

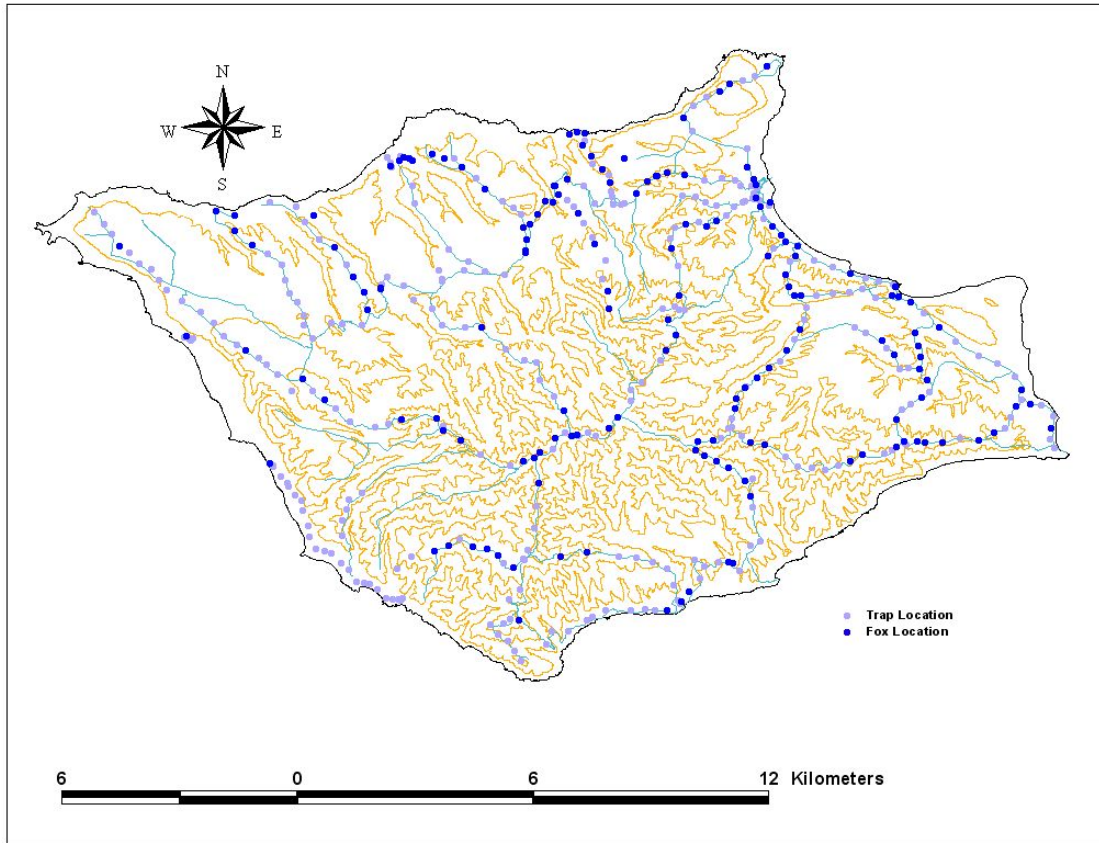


Figure 9. Locations of traps and fox capture sites on 19 transects, Santa Rosa Island, September-December 2008.

trap for this fox when M67 was discovered dead on 19 December, the only injury being a massive head wound. The injury may have been the result of an incomplete predation event, or it could have been due to aggressive encounters with other foxes. As fox densities have increased on Santa Rosa and San Miguel, released foxes have shown greater incidence of injuries from aggression, as well as emaciation (implying a reduced ability to compete, and perhaps evidence of released foxes being driven out of established territories).

Wild Population Monitoring

Trapping was conducted on 19 transects from late July through early December 2008 (Fig. 9). A total of 97 individual foxes were captured, and trap efficiency was 6.1% for individuals and 16.3% for fox captures. Both of these values were one-third of those on San Miguel, and slightly less than Santa Rosa values for 2007 (7.3% and 17.5%, Fig. 10). During the 2008 trapping period, 444 individual skunks (marked with passive integrated transponder tags) were captured. Relative abundance of skunks was over 4X that of foxes. The 39.1% trap efficiency for skunks was less than that of the previous year and confirmed a continued decline in skunks numbers and captures (Fig. 10), as the fox population increases.

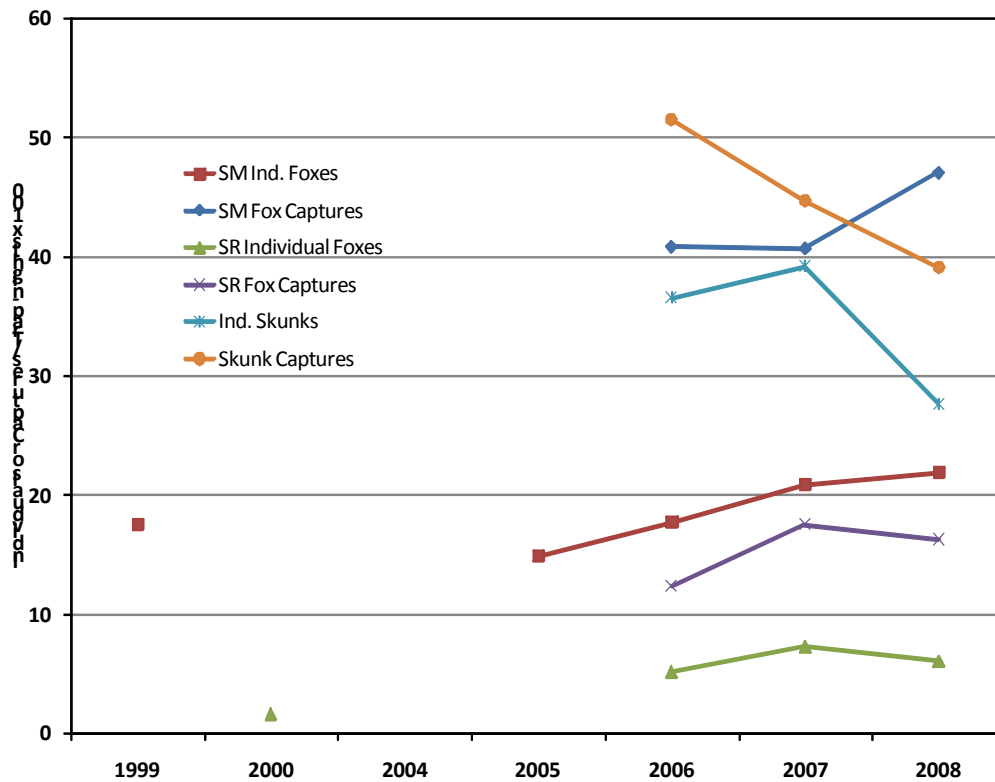


Figure 10. Trap success for island foxes and island spotted skunks during annual population monitoring, San Miguel and Santa Rosa Islands.

The minimum number of Santa Rosa Island foxes known to be alive (MNKA) at the end of 2008 was the sum of the number of individuals caught during fall trapping (97) and the number of radiocollared individuals not caught during trapping but known to be alive (25). At the end of 2008, the MNKA was 122 on Santa Rosa. The actual number of foxes on Santa Rosa is likely higher than the MNKA, which does not account for animals in areas not covered by trapping.

The sex ratio was close to 1:1 for adults (32 M: 29 F) and was exactly 1:1 for pups (18 M:18 F) (Table 15). We used the ratio of pups to adult females in the fall trapping sample to monitor reproductive success. Fall trapping confirmed that 36 wild-born pups had survived through the summer and into the fall, and 6 of those pups were subsequently radiocollared (Table 17). Reproductive success for wild Santa Rosa females was 1.1 pups/female (36 pups/32 females), less than that on San Miguel (1.5 pups/female; Table 12).

Table 15. Number of foxes captured, by age and on transects on Santa Rosa, 2008.

	Pups	Adults	Total
Male	18	32	50
Female	18	29	47
Total	36	61	97

Vaccination of Wild Foxes

All but one captured fox, as well as all released foxes, were vaccinated against canine distemper virus and rabies, with total number of vaccinates being 128 foxes. Up to now we have followed the guidelines for small populations (< 100), that all foxes should be vaccinated for both CDV and rabies, and we will continue to do so in 2009. If trapping in 2009 reveals that the adult population is >100 foxes, in the following year (2010) we will shift to the “vaccinated core” strategy, in which 80-100 foxes in a certain area of the island are vaccinated against CDV (see guidelines for vaccination in Fox Health Working Group report, Schwemm 2008). All foxes will continue to be vaccinated against rabies, since there is no naturally occurring strain of rabies in island fox populations.

Table 16. Island foxes born in the wild on Santa Rosa Island, 2007 and subsequently caught during fall trapping efforts.

PIT Tag	ID	Sex	Captured	PIT Tag	ID	Sex	Captured
0714F	F156	F	9/20/2008	83712		M	8/29/2008
11836		F	8/30/2008	8757D		M	10/12/2008
15765		F	11/7/2008	9283B		F	9/13/2008
22354		M	9/20/2008	96261		M	8/24/2008
26262		F	12/10/2008	A1F4B	F160	F	9/25/2008
34475		F	9/12/2008	A4A78	M54	M	8/21/2008
36417	F154	F	9/6/2008	B2134		M	8/28/2008
4151F		M	9/20/2008	B6C3F		F	9/11/2008
42558		M	11/8/2008	C1C25		F	10/16/2008
4731B		M	11/15/2008	C597A		M	10/9/2008
50218		F	10/3/2008	C6F06	F167	F	10/10/2008
5755F		M	8/23/2008	D4C57		M	9/12/2008
63477		F	9/6/2008	D5522		M	11/14/2008
65D0D		F	10/11/2008	D6642		F	9/20/2008
66F7D		M	8/31/2008	E022A		M	9/19/2008
77509		F	10/19/2008	E1154	M53	M	8/21/2008
80E66		M	9/18/2008	E1C17		M	9/6/2008
82672		F	10/19/2008	F5712		F	8/29/2008

Future Plans

The results of mortality and population monitoring show wild island foxes to be in an improving position on Santa Rosa Island. Although the wild population is still less than half that of San Miguel, despite the fact that releases started a year earlier on Santa Rosa, annual survival remains at a level (>80%) which approximates that on San Miguel. Reproduction in the wild on Santa Rosa (35 pups, 1.1 pups/female) was significantly improved over previous years (2007: 12 pups, 0.8 pups/female).

Monitoring of both the fox population and of individual foxes will continue in 2009. We will maintain a sample of >50 radiocollared foxes on the island. We will conduct population monitoring in summer/fall 2009, and will shift from transect trapping to small, “ladder” grids (Rubin et al. 2006) so that we may estimate population size, and begin to gauge progress toward biological recovery criteria (Bakker and Doak 2009). All newly encountered wild animals will be PIT-tagged, and all captured foxes will be vaccinated against canine distemper virus and rabies.

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Appendix A 2008 Breeding Results for Captive Island Foxes on Santa Rosa Island

Pen 1: 6 year old Female 25D54 was paired with 4 year old male 80C3F. They were first paired in late 2004. In 2005 they had a successful litter of 3 pups. In 2006 they had a successful litter of 2 pups though 4 were seen at the ultrasound exam. In 2007 no pups were seen on ultrasound but gave birth to 2 pups in a late litter which died/disappeared a few days later. No pups were seen at the ultrasound exam in 2008, no late litter was born, progesterone levels were back to baseline in mid-April. She was captured on 06/22/08 for a weight check, no abnormalities or signs of pregnancy were seen. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season. The male was diagnosed with ringworm during the ultrasound exams, the female was clear.

Pen 2: 4 year old Female A5E60 was paired with 4 year old male 7235F. They were first paired in late 2005. They lost a litter in 2005 possibly due to mastitis. In 2006 they had a successful litter of 2 pups, 3 having been seen on ultrasound. In 2007 they had a successful litter of 3 pups after 3 were seen on ultrasound. In 2008 3 fetuses were seen on ultrasound and a successful litter of 3 was raised. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season and successfully reintroduced in mid June once the pups were big enough to defend themselves.

Pen 3: Female yearling 14454 was paired with 5 year old male C4F63. This was a new pairing, they were put together 01/20/08. The female was observed to have 3 fetuses at ultrasound exam due approximately 04/20-04/25. Also during ultra sound exams the female's tail was noticed to have shortened thin to no fur from over-grooming/barbering. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season. On 04/06/08 1 aborted fetus with placenta and 1 placenta were found in her pen. Blood was taken right away and she was given antibiotics. A vaginal culture was taken 05/19/08. No significant findings from the blood and culture results. The fetus and placentas were sent to Dr. Munson at UC Davis. Infection was determined to be a likely cause of the abortion evident from the discoloration of the placenta.

Pen 4: 3 year old female D590E was paired with 3 year old male 64A43. They were first paired in late 2005. In 2006 3 fetuses were seen at ultrasound exams though no pups were ever seen. In 2007 they had a successful litter of 1 pup though 2 fetuses were seen at ultrasounds. In 2008 2 fetuses were seen at ultrasound exams and a successful litter of 2 pups was raised. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season and successfully reintroduced in mid June once the pups were big enough to defend themselves.

Pen 5: Female yearling 60411 was paired with male yearling 13B68. This was a new pairing, they were put together 12/26/08. The female was found to have multiple minor ear wounds on 02/01/08. The pair was separated at that time and the female was put on antibiotics for 10 days. The male was put back into the pen on 02/21/08. No pups were seen at the ultrasound exam in 2008, no late litter was born, progesterone levels were back to baseline in mid-April. The female was captured on 06/22/08 for a weight check, no abnormalities or signs of pregnancy were seen. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season.

Pen 6: 2 year old female C4A1F was paired with 2 year old male 01262. They were first paired in late 2006. They raised a successful litter of 3 pups in 2007 after 3 fetuses were seen on ultrasound. In 2008 2 fetuses were seen at ultrasound exam however no litter was born and her progesterone levels were back down to baseline by mid-April. The female had a 2cm rectal prolapse at the ultrasound exam that was resolved at that time. The female was examined on 04/29/08, 1 week past her estimated birth window. During the exam very small amounts of clear fluid was expressed from her mammary glands, she had no visible signs of mammary or vaginal infection. On 05/19/08 a vaginal culture and blood sample were taken. No significant findings from the blood and culture results. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season.

Pen 7: Yearling female 65F0A was paired with 6 year old male 1271E. This was a new pairing, they were put together on 12/26/08. On 02/13/08 the female was noticed to have a small minor wound to her lower back and some minor wounds to her ears. The male was removed and the female was given antibiotics for 1 week and her wounds were cleaned. On 02/20/08 the wounds to the female were healed, she was given a protective kevlar sweater and the male was put back in to breed. The sweater only lasted the day however no further injuries were observed. No pups were seen at the ultrasound exam in 2008, no late litter was born, progesterone levels were back to baseline in early April. The female was captured on 06/22/08 for a weight check, no abnormalities or signs of pregnancy were seen. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season.

Pen 8: 5 year old female A7954 was paired with 3 year old male B6255. They were first paired in late 2005. In 2006 no fetuses were seen at ultrasound exams and no litter was observed. In 2007 1 very small fetus was seen at ultrasound but no birth observed. In 2008 1 fetus was seen at ultrasound exam however no litter was born. The female was examined on 04/29/08, 1 week past her estimated birth window. During the exam very small amounts of clear fluid was expressed from her mammary glands, she had no visible signs of mammary or vaginal infection. On 05/19/08 a vaginal culture and blood sample were taken. No significant findings from the blood and culture results. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season.

Pen 9: 3 year old female E485E was in pen 9 and she was paired with a few different males over the course of the breeding season. First she was paired with 2 year old male E5066 who she was first paired with in late 2006. In 2007 3 fetuses were seen on ultrasound though no litter was observed. This pair was separated in 05/25/07 due to aggression wounds on female and repaired 10/27/07. Then separated again 12/01/07 again due to injuries on the female then repaired 12/26/07 and separated permanently 01/31/08 after the female sustained more trauma to both ears. Male founder B067E was mistakenly put in with E485E on 03/09/08 and removed on 03/11/08. On 03/12/08 was paired with wild born 2 year old male 51511 who just recovered from severe injuries to his head and neck. The female was not observed to be pregnant at the time of ultrasound exam which eliminated the possibility of E5066 and B067E being the fathers if she had pups. Also at ultrasound exam the females vulva was very swollen and thought likely to be cycling at that time so 51511 was left in the pen for 3 more weeks and was removed on 04/12/08 as part of the new plan to remove all males during pupping season. On 05/06/09 two fetuses were aborted and found in her pen. The fetuses were well developed and had been cleaned, no placentas were found. The female was examined and looked okay. Clear fluid was expressed from mammary glands. Blood and a vaginal culture were taken on 05/18/08. No significant findings from the blood and culture results.

Pen 10: 6 year old female 47304 was paired with male founder B067E. They were first paired at the end of 2004. In 2005 they had a successful litter of 3 pups. In 2006 and 2007 they had successful litters of 2 pups after 2 fetuses had been seen on ultrasound both years. In 2006 B067E sustained severe bite wounds to his tail, which had to be amputated when he was penned with the female and the 2 pups. And in 2007 he sustained severe trauma to his back that resulted in a large abscess with necrotic tissue also sustained when he was penned with the female and 2 pups. On 01/28/08 B067E was brought back to the foxpital for recurrence of the injury to his back, with a new extremely large abscess. Once he was healed he was fitted with a protective kevlar sweater and put back in with 47304. On 03/09/08 B067E was removed from the pen to pair him with another single injury prone female in hopes that he would sire litters with both females. At ultrasound exam 47304 was observed with 1 fetus. She gave birth to and successfully raised 1 pup. Male B067E was not introduced to the pup due to his age and injury history.

Pen 11: 2 year old female 90B2B was paired with 2 year old male 8024B. They were first paired at the end of 2006. The male had a respiratory infection when he was a pup and developed a grade V heart murmur. No litter or fetuses were seen in 2007. In 2008 3 fetuses were observed on ultrasound and a successful litter of 2 pups was raised. The male was removed from the pen in late March at the ultrasound exam as part of the new plan to remove all males during pupping season. The male was not introduced to his pups due to his need of twice daily heart medication. A cardiac ultrasound was done on the male which showed a chronic condition but non-congenital condition so it is not something he will pass on to his offspring.

Pen 12: 4 year old female 31049 was paired with 2 different males. First she was paired with 3 year old male 97541. They were first paired at the end of 2005. In 2006 this pair had 2 fetuses seen on ultrasound exams but never observed to be born. In 2007 they had 2 fetuses seen on ultrasound and born alive but were missing a few days later. Video analysis showed the male eating one of the pups though it couldn't be determined if it was dead or alive. On 01/20/08 the female was found with a large wound to the back of the neck, a recurring aggression injury, now the 3rd time from this male. The wound required surgery and she spent 11 days in the foxpital then put into a pen by herself to heal. On 03/11/08 male founder B067E also just recovering from aggression injuries was moved in with 31049. B067E spent part of the season paired with 47304 in pen 10 and was moved into pen 12 in hopes that he would sire a litter in both pens and since he seemed the best match for this aggression prone female. On 03/13/08 male B067E was found with minor injuries to his ears and was moved to a solo pen overnight and his wounds treated though since they were minor he was put back in the next day. On 03/22/08 the day before ultrasound exams began male B067E was seen with further injuries to his ears and was moved to the foxpital. At ultrasound exam 1 fetus was observed however no litter was born. The female was examined on 05/09/08, 1 week past her estimated birth window. Mammary glands and vagina appeared normal, no fluid expressed from mammary glands. On 05/19/08 a vaginal culture and blood sample were taken. No significant findings from the blood and culture results.

Appendix B Injuries to Captive Island Foxes, 2008

Table 17. Injuries to captive San Miguel Island foxes, 2008.

Date	Fox ID	Sex	Pen	Injury	Treatment
1/21/08	7534A	F	M08	Somewhat constipated	Increase dosage of Lactulose
8/14/08	"	"	"	Sore on neck	Clavamox
10/15/08	"	"	"	Low thyroid hormones noted from blood work at annual exam	Thyroid supplement (thyrozine) 0.1 mg/d

Table 18. Injuries to captive Santa Rosa Island foxes, 2008.

Date	Fox ID	Sex	Pen	Injury	Treatment
Continued from 12/2007	51511	M	From wild	Sustained trauma to head/neck in wild which became severely infected resulting in the loss of 2/3rds of right most of the skin from top of the head and neck in some places tissue loss to skull. Trapped 12/16/08 and brought in for treatment.	2 more surgeries were done in 2008 with varying in between treatments. Mainly staples and sutures to close wound where possible, kept wound clean, bandaged daily with xeroform dressing and a stockinette helmet. Clavamox for 3 months. Released from foxpatal into solo pen 03/04/08.
01/20/08	B067E	M	R10	Ruptured abscess on back with severe pocketing greater than 6".	Brought into foxpatal. Vet removed infected tissue, installed two drains and sutured/stapled closed. Flushed with cefazolin for 5 days. Cefa drops for 3 weeks.
01/20/08	31049	F	R12	Ruptured abscess on back of neck, same location as previous injury, lots of infected scar tissue.	Brought into foxpatal. 2 drain tubes installed, wounds stapled. Butorphanol for 2 days, Clavamox for 3 weeks.
01/31/08	E485E	F	R9	Two gashes to left ear and small hematome on right ear.	Separated from male, wounds cleaned and topical antibiotic applied. Clavamox for 10 days.
02/01/08	60411	F	R5	Multiple minor healing wounds to both ears	Separated from male and cleaned wounds. Clavamox for 10 days.
02/13/08	65F0A	F	R7	Small minor wound to right side of lower back and to ears.	Cleaned wounds, antibiotics for 1 week. Removed male from pen

ISLAND FOX RECOVERY REPORT

Date	Fox ID	Sex	Pen	Injury	Treatment
					for 1 week.
03/13/08	B067E	M	R12	Irritated right eye, multiple minor ear wounds	Flushed eye, cleaned wounds applied topical antibiotic. Moved to solo pen for 1 night.
03/22/08	B067E	M	R12	Hematoma to and deep wounds to ears and back of head	Surgery to place drain tube and staple 1 wound shut other left open to heal. Cleaned wounds and topical antibiotic to wounds BID. Cefadrops BID, had suppressed appetite so gave fluids, vitamin B, nutritional 3 days. Further complications see 04/06/08
03/23/08	C4A1F	F	R6	2cm rectal prolapse at ultrasound exam	Prolapse was reduced manually and topical antibiotic was applied.
04/06/08	B067E	M	Foxpital	Grape sized mass found on lower abdomen. Possible ring worm. After being observed to have severe spodylosis on spine.	Attempted to drain mass but no fluid inside. Still recovering from previous head/ear wounds being treated BID. 04/18/08 X-ray of mass then surgery to remove mass which appeared to be glandular. He was also given an antifungal bath and treated with limesulfur dip for possible ringworm. Already on daily cosequin for life.
04/25/08	8024B	M	24Y	Cardiac ultrasound to access heart murmur showed chronic, noncongenital heart condition, enlarged right ventricle and thickened wall, left and right atrial enlargement affecting both pulmonic and tricuspid valves. Liver has enlarged hepatic vessel and portal hypertension. Previous pulmonary hypertension damage from pneumonia.	Started on ¼ tablet vetmadin BID indefinitely. Not expected to live long. Will require further care in the future.
03/24/08	14454	F	R3	Barbered tail	No treatment, eventually fur grew back.
03/24/08	80C3F	M	R1 -> R17	Ringworm: 4cm lesion behind left ear	Cleaned with chlorahexadine and applied clotrimazole 3 times in first week. Then lime-sulfur dip weekly for

ISLAND FOX RECOVERY REPORT

Date	Fox ID	Sex	Pen	Injury	Treatment
04/06/08	14454	F	R4	Aborted fetuses	3 weeks when was clear. Brought into foxpital for observation and given Baytril for 5 days. Blood taken. Vaginal culture taken at later date.
05/06/08	E485E	F	R9	Aborted fetuses	Examined, looked okay. Blood and vaginal culture taken on 05/18/08.
06/09/08	31049	F	R12	Grass seed in right eye	Seed removed from eye and eye flushed with saline. Next day brought to foxpital dyed eye to check for ulceration none found. Flushed with saline and applied BNP BID for 3 days.
07/08/08	B067E	M	R18	Did not eat for 3 days, lethargic	Just monitored closely fed a mouse or quail daily which stimulated appetite. Was ready with fluids and vitamin B complex but they were not needed. Was eating and as active as normal by the end of the week. Had lost some weight.
07/28/08	51511	M	R9	Reopened previous neck wound	Brought to foxpital and cleaned wound. Bandaged daily with xeroform dressing and a stockinette helmet for 3 weeks. Clavamox for 3 weeks.
08/13/08	C4A1F	F	R6	Rectal Prolapse noticed during feeding	Prolapse was reduced manually
08/16/08	C4A1F	F	R6	2 nd rectal prolapse of week noticed during feeding, was swollen and dirty. Also had bite wounds to right ear with a small hematoma.	Cleaned rectum and reinsured, applied antibiotic moved to solo pen. Prolapse recurred brought to foxpital. Anesthetized cleaned and treated rectum, re-inserted and held with purse-string sutures. Given Laxatone and mineral oil (few weeks), Baytril (10days) and 2 rounds of doramectin.

Appendix B Island Foxes Currently in Captivity

Table 19. Island foxes in captivity, San Miguel and Santa Rosa Islands, 2009.

Pen	PitTag	Studbook Number	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
<i>San Miguel</i>									
M08	7534A ¹	14	F	16	Wild			9/4/1999	Nidever Canyon
<i>Santa Rosa</i>									
R10	B067E ²	24	M	10	Wild			3/26/2000	Smith Highway
R11	8024B	348	M	2	Captive	85420	2410E		

¹euthanized 18 April 2009, due to fractured vertebra and permanent paralysis

²died 13 March 2009 from extensive hemorrhage in peritoneal cavity