

**National Park Service
Channel Islands National Park**

***ISLAND FOX CAPTIVE BREEDING PROGRAM
2002 ANNUAL REPORT***

Technical Report 03-01

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May 2003

ACKNOWLEDGEMENTS

The island fox captive breeding program at Channel Islands National Park continues to grow each year and would, without a doubt, not be possible without the team effort that has contributed to its current status. We thank the many people whose time, efforts and expertise have kept the program going.

We owe the greatest debt to the island fox caretakers. Our staff provides the daily care and enriched environments for the foxes that keep them healthy and productive, the primary goal of any captive breeding program. The importance of these caretakers can never be overstated and the program would not work without them. So as we say a farewell to Stacy Lehman we welcome our newest caretakers Pedro Chavarria, Geoff Cline, and Zac Nelson. We continue to depend on Susan Coppelli, Andrea Lehotsky, and Todd Russell for not only their excellent fox care, but also their observations and insights that continue to improve our program. Others have volunteered their time to caretake for the foxes, some on short notice or to cover periods when our staff could not be on the islands. We thank Ian and Marcella Williams, Tom and Donna Dore, Don, Susan and Allie Morris, James R., Georgianna and Katie Chess, Ray and Lorrie Aichner, Jeremy Moynier, Julia Parker, Jana Edwards, David Kushner, Julie Christian, and Andrea Moe.

Thanks to Lynn Lozier and Erik Aschehoug of The Nature Conservancy for their support in island fox recovery actions on Santa Cruz Island, including construction and staffing of the captive breeding facility. That facility is staffed by the Institute for Wildlife Studies, and so we continue to benefit from the vast island fox experience of that organization. Thanks to IWS president Dave Garcelon and his dedicated staff: Pete Sharpe, Mitch Dennis, Kara Randall, Chris Newman, Geoff Cline, and Zac Nelson.

Construction of the Santa Cruz Island fox captive breeding pens required significant labor and volunteers provided the bulk of this labor. For this effort we thank Geoff Cline, Tim Webber, Erica Gies, Chris Couch, Chris Newman, David Kushner and Julie Christian. Support was also greatly appreciated from on-island personnel Darcy Macdonald, Tim Jones, and Sam Spaulding. Brent Wilson, Keith Duran, and John Provo ably provided landing craft service for delivery of pen materials to the islands.

San Miguel Island manager Ian Williams has assisted in all phases of the program on San Miguel, including fox monitoring and capture, pen construction, fox care and feeding, veterinary care, and development of a camera monitoring system. We appreciate his continued interest and assistance.

We thank our project veterinarian, Mark Willett, for conducting veterinary exams, and providing veterinary care to foxes. When circumstances required immediate veterinary care, time and effort were kindly donated by veterinarian Keri Miliken. Melissa Gray, Erica Gies, and Maggie Dwyer provided assistance with veterinary exams during the 2002 season.

We thank director Rich Block of the Santa Barbara Zoo for making the zoo an effective partner in island fox captive breeding at the Park. Rich, along with General Curator Alan Varsik and Assistant Curator Ingrid Russell, have kindly donated their staff's time for veterinary and fox care on the islands, and we have learned much from their staff's experience with captive island foxes. Thanks to Alan Varsik and Julia Parker of the Zoo for maintaining the island fox studbook.

Analysis of blood, fecal, tissue and other samples from captive foxes was provided by Linda Munson of UC Davis. Thanks to Cheri Asa and Joan Bauman of the St. Louis Zoo for hormonal monitoring of captive foxes. Genetic analysis of the captive island fox populations was conducted by Melissa Gray and Gary Roemer; thanks also to Kathy Ralls and Jonathon Ballou for their assistance.

Guidance for the program has been provided by members of the captive breeding working group and others, who have donated time and expertise to program oversight. We thank Kathy Ralls, Cheri Asa, Marsha Sovada, Linda Munson, Bob Wayne, Phil Miller, Dave Garcelon, Mark Willett, Alan Varsik, Ingrid Russell, Julia Parker, and Melissa Gray. Their professional expertise and genuine concern for the fate of the island fox has helped immensely in shaping the island fox captive breeding program.

Thanks again to Rhonda Brooks, Fred Rodriguez and Doretta Burgess for once again effectively coordinating transportation to the islands. We particularly appreciate the skills and efforts of the Park's boat crews in getting us and our materials onsite. For this we thank Brent Wilson, John Provo, Dwight Willey, Keith Duran, and Diane Brooks.

Don Jones provided the cover photo.

Thanks finally to the Park management team and the rest of the Park staff for supporting these critical emergency actions for island fox recovery. We especially appreciate the support of Kate Faulkner, Chief of Natural Resources Management. Island fox conservation has grown from a local, Park issue to being a critical natural resource need, and we appreciate the efforts of those beyond the Park who have recognized the need and helped garner the resources necessary to effect recovery. For this we thank Dave Graber, Peter Dratch, Cathy Schwemm, Bridget Fahey, Patty Neubacher, Jim Shevock, and Jay Goldsmith.

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photos by Geoff Cline

Island fox captive breeding facility, Santa Cruz Island: a and b) climbing structures and tunnels; c) in pursuit of live prey from feeding corral; d) Chinese take-out; e) piggy-back on mom; f) the weekly quail.

Executive Summary

In 1999, the National Park Service established a captive breeding program for island foxes (*Urocyon littoralis*) at Channel Islands National Park. The Service took this action to preserve and restore wild populations of island foxes to viable levels following dramatic declines in island populations on three of the islands managed by the Park. During 2002, the captive population of island foxes on Santa Rosa and San Miguel Islands increased from 51 to 72 animals with the production of 21 pups in spring 2002 (Fig. 1). In

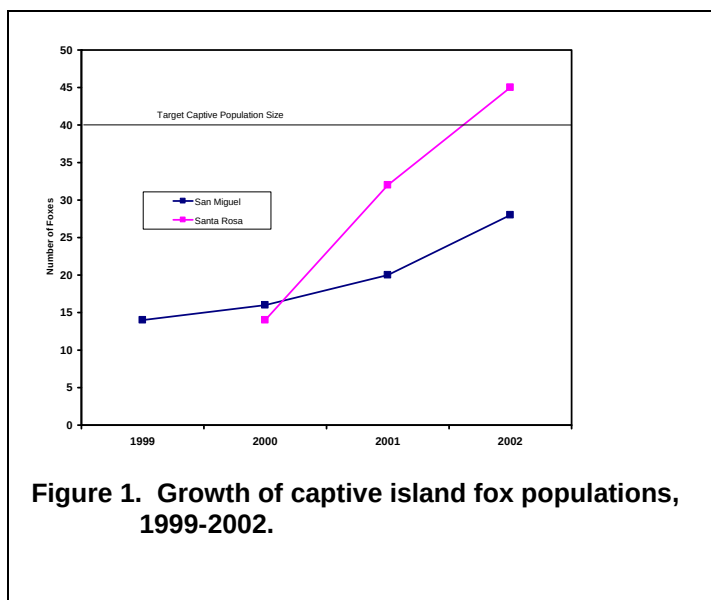


Figure 1. Growth of captive island fox populations, 1999-2002.

February 2002, a 10-pen captive breeding facility was built by the Park on Santa Cruz Island with assistance from The Nature Conservancy and The Institute for Wildlife Studies. Trapping efforts by the Park and the Institute brought 12 adult island foxes into captivity by March 2002. One of the 6 females brought in produced a litter of 5 pups in the spring. Capture of additional animals brought the Santa Cruz captive population to 20 animals by December 2002. The total Park captive population comprises 93 animals on 3 islands.

In 2002, 13 pups were born to 6 litters on Santa Rosa Island, increasing the island population from 32 to 45 foxes. Eight pups were born to 3 litters on San Miguel, increasing that captive population from 20 to 28, with 1 animal left in the wild. One litter, the largest recorded for captive island foxes (5), was born on Santa Cruz Island. Ten of 23 paired females, or 44%, produced litters in 2002. Sex ratios in captive litters were skewed towards males on Santa Cruz and San Miguel, and towards females on Santa Rosa. To date no captive-born female has produced a litter (0 out of 7), and only 3 out of 10 female founders on San Miguel have bred. The average number of pups produced per litter was 2.4 over the 3 years of captive breeding.

In October, pairings were made for the 2002-2003 breeding season. There are 12 pairs on San Miguel, 16 pairs on Santa Rosa, and 10 pairs on Santa Cruz. Genetic analysis conducted on the captive fox populations was again used to select pairings on San Miguel and Santa Rosa Islands, although pairing choices on San Miguel are limited at this time because 2 of the 3 successful breeding pairs are directly related. Mates were swapped between 2 pens on San Miguel because of a lack of reproductive success in those pairs. Genetic analysis of the Santa Cruz captive island fox population had not been completed by the time pairings were made, so pairings were instead based on telemetry data and the geographic area of capture.

Captive foxes received regular veterinary examinations during the year. Blood samples were taken for blood chemistry and hematology, with no results of any clinical significance. In December 2002, a fecal parasite survey was initiated across the 3 northern islands. The survey, conducted by the USGS National Wildlife Health Center and the University of Tennessee, will form the basis for a risk assessment of internal parasites in the captive island fox populations. Results from the survey will be presented at the 2003 Island Fox Conservation Working Group meeting.

Captive foxes on San Miguel harbor 3 parasites with potential to impact fox health: *Angiocaulus*, *Spirocerca* and *Uncinaria*. No foxes were treated for parasites in 2002, because none showed clinical signs warranting treatment and a conservative approach has been taken due to the unknown effects of treatment on foxes. Foxes on Santa Rosa have not tested positive for *Angiocaulus* and show little sign of *Uncinaria*, but appear to have spiroceroids. Some foxes on Santa Rosa and Santa Cruz had significant flea infestations, and were treated during annual veterinary exams. Two foxes on Santa Rosa Island were brought into the island vet facility during annual exams due to a wound infection and a prolapsed rectum. Both were treated and eventually returned to their respective pens. On Santa Cruz an injured fox was brought in from the wild in April 2002, and 1 of its digits was removed. The female was subsequently paired with a male captive pup for the 2003 season.

In 2002 the veterinary care working group of the Island Fox Conservation Working Group recommended vaccinating all captive island foxes against canine distemper virus, which caused the recent fox decline on Santa Catalina Island. Accordingly, all adult captive island foxes on San Miguel, Santa Rosa and Santa Cruz Islands were vaccinated with the monovalent recombinant canine distemper virus vaccine in 2002. Vaccination requires an initial injection and a booster administered approximately 1 month later.

The Park attempted 2 golden eagle net - gunning operations in 2002. Both operations failed to capture golden eagles, due to inclement weather, unsuitable terrain, and dense vegetation. By the end of 2002 there were an estimated 10 golden eagles on Santa Cruz Island, and 5 on Santa Rosa. Subsequent surveys on Santa Rosa indicated 2 breeding pairs of eagles on that island. Bow - net trapping efforts in winter 2003 resulted in the capture of 6 eagles on Santa Cruz Island.

With growth of the Santa Rosa island fox captive population to 45 foxes, the captive population goal of 40 foxes was exceeded. Consequently a draft release strategy plan was released in November 2002, for an experimental release of island foxes on Santa Rosa in January 2003. The release would have occurred if golden eagles were absent or in low numbers on Santa Rosa, and if no further fox mortalities were recorded from the radiotelemetry study on Santa Cruz Island. That study showed >70% survivorship for island foxes with 3 - 7 golden eagles present during much of 2002. Genetic information on the captive population was used to identify individual foxes that were genetically "surplus" to the captive population. The reintroduction was to follow a December 2002, release of 3 male pups on Santa Cruz Island. However, conditions did not allow for release on Santa Rosa. In December 2002, during the annual deer and elk aerial survey on Santa Rosa, 5 individual golden eagles were spotted. Because of the sightings and low survival rates for the 3 pups released on Santa Cruz (2 out of 3 died in the first 2 weeks due to predation) the Rosa release was postponed pending removal of golden eagles from the island.

In December, 2001, the U. S. Fish and Wildlife Service proposed to list as endangered the following 4 island fox subspecies: San Miguel island fox (*U. I. littoralis*), Santa Rosa island fox (*U. I. santarosae*), Santa Cruz Island fox (*U. I. santacruzae*), and Santa Catalina island fox (*U. I. catalinae*). As of May 2003, FWS had not issued a final rule on listing.

In 2002 the NPS released a final restoration plan for Santa Cruz Island, the primary restoration action being the removal of feral pigs from the island. Pig removal could take 5 - 6 years to complete, and may begin in 2003. The NPS is also cooperating with other agencies in a feasibility study to determine if bald eagles (*Haliaeetus leucocephalus*) can be restored to the northern Channel Islands. In the summer of 2002, 12 eaglets were reintroduced to Santa Cruz Island, and 7 remained on the islands as of May 2003. Annual supplementation with up to 12 eagles a year will continue until 2007.

The Island Fox Conservation Working Group, a loose affiliation of entities concerned with conservation of island foxes, met again in 2002 to consider current conservation challenges faced by the species. Primary issues identified by the group were:

- the continued predation by golden eagles on island foxes in the northern Channel Islands, and the threat posed by eagles to island fox recovery;
- the threat posed by canine distemper virus to captive and wild populations; and
- the genetic and demographic consequences of small population size for the 3 northern subspecies

Introduction

Background

The island fox, a diminutive relative of the gray fox (*U. cinereoargenteus*), is endemic to the California Channel Islands. The fox exists as 6 different subspecies on each of the 6 islands, a distinction upheld by morphological and genetic work (Wayne et al. 1991, Collins 1993). The subspecies on the 3 northern Channel Islands are in genuine danger of extinction from unnatural levels of golden eagle predation and from extremely low population levels.

In December 2001, the U.S. Fish and Wildlife Service proposed for listing as endangered 4 subspecies of the island fox, including the 3 subspecies in the Park (San Miguel Island fox [*U.I. littoralis*]; Santa Rosa Island fox [*U.I. santarosae*], and Santa Cruz Island fox [*U.I. santacruzae*]) as well as the subspecies on Santa Catalina Island (*U.I. catalinae*). A final rule listing those subspecies as endangered has not been published.

Island fox populations were annually monitored on San Miguel Island from 1993 to 1999, and on Santa Cruz Island from 1993 to present. The island fox population on San Miguel declined beginning in 1994 with the adult population falling from 450 in 1994 to 15 in 1999 (Coonan et al. in review). The Santa Cruz population declined from approximately 2,000 adults in 1994 to perhaps less than 135 in 2000 (Roemer 1999), and the current population is probably less than 100 adults (D. Garcelon, Institute for Wildlife Studies, unpubl. data). Survey data from Santa Rosa Island (G. Roemer, Institute for Wildlife Studies, unpublished data) indicate that island foxes experienced a similar catastrophic decline on that island as well. 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 non - native golden eagles (*Aquila chrysaetos*) is the primary mortality factor now acting upon island foxes on the northern Channel Islands, and is likely 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, and another 2 died of unknown causes (Coonan et al. in review). In 2001 - 2002, 15 of 18 mortalities of radiocollared foxes on Santa Cruz Island were due to golden eagle predation (D. Garcelon, Institute for Wildlife Studies, unpubl. data).

The observed level of golden eagle predation is unnatural. Until recently, golden eagles have never bred on the Channel Islands and their recent appearance is due to a prey base, feral pigs (*Sus scrofa*) that was not present prehistorically. The absence of bald eagles (*Haliaeetus leucocephalus*), which bred historically on the islands and whose presence may have kept golden eagles away, is another factor contributing to golden eagle predation. Moreover, on much of the northern Channel Islands, historic sheep grazing changed the predominant vegetation from shrub to non-native grasslands, which offer much less cover from aerial predators.

Upon receiving recommendations from a convened panel of experts, the Park began taking emergency recovery actions in 1999. In summer 1999, the Park constructed pens on San Miguel and began capture of wild island foxes. By January 2000, 14 island foxes had been captured and placed in the pens. Four of those were males, and so were paired with 4 females for breeding. The captive population on San Miguel increased from 14 to 28 animals after 3 years of breeding, and there is only 1 fox left in the wild on the island. A successful 2003 breeding season (>10 pups) could put the captive San Miguel island foxes in position for releases in fall 2003.

A captive breeding program was initiated for Santa Rosa Island in 2000. The initial captive population on Santa Rosa was 14 animals, which proved to be the island's remaining fox population. Some females were pregnant when captured, and 3 litters were born in captivity in 2000. With an increase to 45 foxes in 2002, the captive population on Santa Rosa exceeded the target captive population size of 40 foxes. The facilities on Rosa are currently at maximum capacity and if releases are not possible in fall 2003, additional pen space will be needed.

The status of eagles and foxes on Santa Cruz Island was assessed at the 2001 Recovery Team Meeting, and indications were that captive breeding was warranted for that island fox population. In February 2002, a 10-pen captive breeding facility was built on Santa Cruz Island by the National Park Service and The Nature Conservancy. This facility was stocked with 12 adult island foxes caught in pairs or as individuals from separate areas of the island. One of the pairs gave birth to a litter of 5 pups in the spring and by December 2002, 20 animals were housed in the facility.

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 are now known to breed on both Santa Cruz and Santa Rosa Islands. To date 28 golden eagles have been removed from Santa Cruz Island, the bulk by bownet trapping. Captured birds were released in northeastern California, and satellite telemetry indicates none have attempted to return to the islands. Approximately 3 eagles remain on Santa Cruz and 4 on Santa Rosa.

In March 2001, the Park released a draft recovery plan for island foxes on the northern Channel Islands (Coonan 2001). The recovery plan is in the format of U.S. Fish and Wildlife Service recovery plans, 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. 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 recovery plan 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. Full recovery of the San Miguel subspecies may take as long as a decade, although recovery on Santa Rosa and Santa Cruz may occur sooner. The plan was developed with input from U.S. Fish and Wildlife Service, and is likely to be adopted as part of a FWS recovery plan for the species, should the species be listed. The final island fox recovery plan should be released in summer, 2003.

Since 1999, the NPS has 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 is called, is a loose affiliation of public agency representatives, landowners, conservancies, zoological institutions, non - profits and academics concerned about conservation efforts for the island fox.

The island fox is in decline on 4 and perhaps as many as 5 of the 6 Channel Islands on which it occurs; the species is listed as Threatened by the State of California but is currently not Federally listed as Threatened or Endangered. Because there is no coordinated recovery program for this non - listed species, the working group serves as a forum for information exchange and evaluation of recovery efforts. The working group communicates primarily through an annual meeting, but also via email and telephone conference calls. The group further divides into subject matter groups to tackle most issues. The individual working groups for this year's meeting were captive breeding, veterinary care, wild population management, and public policy and education. The group 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).

The Need for Captive Breeding as a Recovery Action

The Park's island fox recovery plan (Coonan 2002) identifies captive breeding as a critical recovery element necessary to recover island fox populations to viable levels on the northern Channel Islands. Current island fox populations on San Miguel, Santa Rosa, and Santa Cruz Islands number 29, 45, and <100 foxes, respectively. The probability of extinction is high for these critically low populations (Roemer et al. 2001b) and the populations require augmentation to reach viable levels. Demographic work indicates that an appropriate augmentation schedule can return island foxes to viable population levels within a reasonable timeframe (a decade). The original island fox recovery team and the current Island Fox Conservation Working Group recommend captive breeding as a recovery action. Once golden eagles are removed from the northern Channel Islands, captive breeding will be the most important recovery action implemented for island foxes, and will require commitments of resources and personnel far exceeding any other recovery action. In this context we report on the status of the program after 3 years of breeding.

Captive Breeding Program Development

Although captive breeding of island foxes on the northern Channel Islands was originally begun as a “sanctuary” program to protect a portion of the population from predation, the low populations required the program to focus on producing enough foxes to allow annual releases into the wild sufficient to recover wild populations. In this respect, program development has been a work in progress. What began as 2 pens, 2 foxes, and 2 field staff in April 1999, is currently 93 foxes spread across 5 facilities (50+ pens) on 3 islands and a field staff of 6.

Demographic modeling (Roemer et al. 2001b, Coonan 2001) was used to set an augmentation schedule that would annually produce sufficient foxes to return the wild populations to viable levels. Program scope, facility size and configuration were set accordingly. Currently, Santa Rosa Island has met the population goals for the captive facility and release plans were developed for 2003. The San Miguel population has not yet reached the targeted captive population size of 40 foxes. The San Miguel captive population doubled in size in 3 years, and the target population size could be reached with production in 2003. On Santa Cruz there are 10 captive pairs and future plans on the size and scope of the Santa Cruz facility will be developed as the captive population grows, more information on the wild population is gathered, and the golden eagle relocation effort progresses.

Goals and Objectives for Captive Breeding

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

OVERALL GOAL

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

OVERALL OBJECTIVE

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

SPECIFIC OBJECTIVES

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

Program Guidance

Guidance for the captive breeding program is provided generally by the captive breeding and veterinary sub - groups of the Island Fox Conservation Working Group. For guidance in design of captive enclosures and development of husbandry protocols, we consulted the American

Zoological Associations' management recommendations for small canids in captivity, as well as the American Society of Mammalogists' guidelines for the capture, handling and care of mammals (American Society of Mammalogists 1987).

Previous guidance has been provided by the captive breeding sub-group of the Island Fox Conservation Working Group on program development, and was incorporated into the Park's captive breeding program (Coonan and Rutz 2001, 2002). Further guidance was provided by the Island Fox Conservation Working Group in June 2002. Full discussion of these issues is contained in the 2002 meeting notes (see Appendix B), and the following summarizes the resulting recommendations:

1. The overriding threat to the 3 northern subspecies continues to be golden eagle predation. The effect of eagle predation, and the extent to which it can be minimized, will determine the success of recovery efforts. Release of island foxes back into the wild on Santa Rosa Island is contingent upon a lack of eagles on that island. Eagle surveys should be conducted prior to release to determine presence or absence of eagles. Intensive post-release monitoring should be conducted for fox survivorship and eagle presence. If significant predation occurs, foxes may be brought back into captivity. To prevent attracting and supporting golden eagles, the current hunt for deer and elk on Santa Rosa should be managed so as to remove all carrion (gut piles) from the field.
2. The Santa Rosa captive fox population is nearing facility capacity, and release of animals into the wild is imminent. Choice of animals to be released is important. Recommend that the first release comprise 2 family groups released in the fall, with additional extra females released to facilitate extra-pair copulations. Prior to release the pedigree for the captive population should be refined, and animals should be chosen for release so as to minimize genetic impact to both the captive and wild populations.
3. Aggression during the breeding season has been recorded in both the zoo and island captive populations, with some considerable injury to individual foxes. The problem does not seem to be widespread. Recommend that pens not have common fences, and installing perimeter fences around all pens on islands that have free-ranging foxes.
4. Some fox pairs in captivity, particularly on San Miguel Island, have failed to reproduce in 3 years. The breeding failures may be due to failure to mate, male infertility, embryo/fetal loss, or infanticide. Recommend a variety of investigative techniques to discern cause:
 - Direct observation or video to document occurrence of courtship and mating behavior, infanticide
 - Fecal testosterone and semen collection to determine male infertility
 - Pregnancy diagnosis by ultrasound or relaxin blood test
5. Canine distemper virus, which caused the recent island fox decline on Santa Catalina Island, is the disease of most concern, but also one for which there is a safe vaccine. To protect captive fox populations from possible introduction of canine distemper virus, recommend vaccinating all captive foxes with monovalent recombinant canine distemper virus vaccine.
6. Many foxes whose serum was recently tested had antibodies against canine parvovirus. Because parvovirus accumulates in the environment, most wild foxes are exposed to small doses, which may confer some protection. Because the parvovirus vaccine has limited effectiveness, requires frequent boosters, and not been tested for safety in island foxes, vaccination is not recommended at this time. Vaccination against rabies or canine adenovirus is also not recommended at this time.

7. The University of California has taken the lead on disease surveillance in island foxes. These efforts should be continued, and all agencies and landowners should cooperate. Methodologies include annual veterinary exams of captive foxes, serology, hematology, clinical chemistry, fecal analyses, ectoparasite evaluation, and complete postmortem exams on all foxes that die.
8. The USGS-Biological Resources Division Wildlife Health Center is conducting an evaluation of parasites in captive island foxes. To determine the current extent of parasite problems, sampling protocols have been developed and should be implemented beginning in fall 2002. Whereas the lack of clinical signs indicates that treatment is not warranted at this time, the concentration of animals in small areas could lead to problems. Captive pens should be managed to minimize build-up of parasites in the environment. Recommend removing feces daily, and disposing of feces at a more distant location. Treatment protocols will be developed, in the eventuality that clinical signs indicate treatment is necessary.
9. Knowledge of previous exposure to canine viruses is essential for determining disease threats, and for making decisions regarding vaccination. Serum collected from wild and captive island foxes in 2002 should be assayed for canine diseases. As time and funding permit, archived serum from previous years' sampling should be assayed.
10. Consistent protocols for medical procedures and sample collection would be advantageous for assessing overall population health and conducting investigations. Some veterinarians already have protocols in place that could serve as templates for the island fox program; these protocols should be circulated among the island fox veterinarians for review and then distributed to all sites and investigators working with island foxes.
11. The potential for transmission of disease from domestic and feral animals remains a grave concern. Health requirements should be established for dogs coming onto the islands, such as dogs used in pig removal operations.

Standard Operating Procedures

The following standard operating procedures have been developed for the captive breeding program:

Facility Design and Construction

- In order to minimize the chance of disease, parasites or other catastrophe causing extirpation of captive populations, San Miguel and Santa Rosa Islands each have two separate breeding facilities.
- Staff level must be adequate for caretaking 40-50 animals at two sites.
- Sufficient distance is maintained between pens, while within the pens hiding places are provided; thus animals have visual contact with others when they choose.
- Annual pen construction is completed by October to allow pairs sufficient time to bond prior to breeding.
- There should be a minimum of two isolation areas at each facility.
- The threat of wildfire at captive breeding facilities is addressed by the Park's fire management program, and Vari-Kennels are available for immediate evacuation of foxes.

Veterinary Care

- If foxes are brought to the mainland for veterinary care, they cannot be returned to the islands, because of possible disease/parasite transmission.
- Captive foxes are given regular veterinary examinations, using a standardized veterinary protocol.
- Each captive breeding population has access to a veterinary/quarantine facility where animals may be treated.
- Protocols are implemented to minimize the risk of people or equipment transferring pathogens among islands, and to minimize parasite loads in the captive populations.

Caretaking and Handling

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

Breeding Strategy

- Mated pairs are kept together as long as they reproduce successfully; non - reproductive pairs are kept together for at least two breeding seasons.
- Pairings of siblings or parent/offspring are avoided using genotyping of individual animals, and estimation of relatedness.
- Video monitoring is used to the extent practicable to document breeding behavior or lack thereof, and to record birth dates, pup fate, and neonatal care.
- Captive - born foxes are preferentially paired with wild - born individuals, as long as this doesn't break up existing pairs, to minimize loss of wild behavioral traits.
- Birth, death and breeding records are maintained in a studbook.
- Excess females may be housed together if compatible to allow for social interaction or to possibly test reproductive potential of one male with two females.

Diet

- The fox diet comprises a high - quality dry dog (24% crude protein, 14% crude fat) (Innova® Dog Food™, Natura Pet Products, Santa Clara, CA) supplemented with hard - boiled eggs, and a variety of fruits and vegetables. This is supplemented several times per week by live deer mice or dead coturnix quail.
- Captive foxes are not given moist meat - based food, such as canned cat or dog food, or fruits high in citric acid, since they may cause gingivitis and tooth loss.
- The amount of food given daily is on average 3 - 4% dry weight of the foxes' body weight (i.e., a 2.3 kg adult receives 90 g of food daily).
- During breeding season, females suspected to be pregnant or with litters are fed dog kibble with higher crude protein (26%) and more essential fatty acids (Innova® Puppy Food™, Natura Pet Products, Santa Clara, CA). Family groups are fed this diet until the pups reach adult body size (October).

Captive Breeding Program Status

Overall Breeding Success

In 2002, the San Miguel captive population increased from 20 to 28 individuals, with 8 pups born to 3 litters. On Santa Rosa the captive population increased from 32 to 45 individuals with 13 pups born to 6 litters. The litter on Santa Cruz increased that captive population to 17 foxes; after release of several of the pups, and capture of additional adults for breeding, the captive population is at 20 animals (10 pairs).

Ten of 23 paired females produced litters in 2002 (44%), compared to 7 of 13 in 2001 (54%), and 4 of 7 pairs in 2000 (57%). The percentage of successfully breeding females declined because no captive-born female has produced a litter (0 of 7), and only 3 out of 10 female founders on San Miguel have bred. Thus the number of founders remains low on San Miguel (5; see Appendix C). This is, in part, a consequence of a lack of males. Only 4 of 14 animals brought into captivity in 1999 were males. On Santa Rosa, 6 of 13 pairings have reproduced successfully since 2000, and the number of founders is 11 (Gray et al. 2002).

Overall, reproductive output is similar to that observed in the wild. The average number of pups weaned in captive litters (2.4, $n = 21$ litters) is only slightly higher than the average number of pups weaned in the wild on San Miguel from 1993 to 1998 (2.0, $n = 34$) (Coonan et al. in review). Among the captive populations, the number of pups weaned per litter was slightly higher on San Miguel (Table 1).

The proportion of females that produced litters was also similar to that observed in the wild. In captivity, 17 of 21 annual pairings (44.7%) have produced litters (Table 2), compared to 42.8% in the wild (54/126 pairings; Coonan et al. in review). The proportion of females breeding was higher on Santa Rosa than on San Miguel (Table 2).

Female age was a factor in reproduction, as in the wild. The proportion of Age Class I females (1 - 2 years old) breeding in captivity was 21.4%, similar to the 19% observed in the wild (Coonan et al. in review). The proportion of older females that bred in captivity (58.3%) was similar to that observed in the wild on San Miguel (60.0%; Coonan et al. in review). However, there was a difference between islands in the breeding success of older females. Nine of 10 older female pairings produced a litter on Santa Rosa, but only 5 of 14 did so on San Miguel. This reflects the general lack of breeding success by possible founders in the San Miguel population.

Mate history affected likelihood of breeding. Most captive fox pairs were not successful in their first year of mating. Only 30.4% of 23 first-year matings were successful, whereas 66.7% of 15 second and third-year matings were successful.

Table 1. Average number of pups weaned per litter, 1999-2002.

Island	Avg. No. of Pups Weaned	n
Santa Cruz	5.00	1
San Miguel	2.50	6
Santa Rosa	2.21	14

Table 2. Proportion of annual pairings that have produced litters, 1999-2002.

Island	Litter	No Litter	Total	% Success
San Miguel	6	12	18	33.3
Santa Rosa	11	9	20	55.0
Total	17	21	38	44.7

Another factor affecting the growth of the captive populations is the uneven sex ratios in the captive-born litters. There were 11 unmated animals on Santa Rosa and San Miguel in 2001, 8 unmated animals in 2002, and 17 unmated animals for the 2003 breeding season.

In summary, reproductive success for captive foxes was similar to that of wild foxes from San Miguel from 1993 - 1998. Age Class I females rarely bred, and the average number of pups weaned was similar for captive and wild foxes. First-year matings were successful only a third of the time. The primary difference between San Miguel and Santa Rosa was the relative failure of older females to breed on San Miguel.

San Miguel Island Captive Breeding Facility

Breeding Success

During 2002, the San Miguel captive population grew from 20 to 28 foxes (Tables 3 and 4), with 1 fox left in the wild. Eight pups, 6 males and 2 females, were born to 3 litters in April 2002 (Table 5). Seven other pairings did not produce litters. Of the 7, 5 were first-year pairs and less likely to breed. The other 2 pairs also failed in 2000 and 2001, and were assigned new mates for the 2002 - 2003 breeding season.

In October, pairings were made for the 2002 - 2003 breeding season. There are 12 pairs on San Miguel for the breeding season. There are currently 4 unmated males on San Miguel.

Genetic analysis conducted on the captive fox populations (Gray and Roemer 2001) allowed determination of relatedness among foxes and was used to select pairings. There was substantial overlap of relatedness ("r") values for related and unrelated foxes on San Miguel, due to the lack of genetic variation in the population. In fact, the level of genetic variation in the population has declined since 1988 (Gray and Roemer 2001). Both failed pairings in 2000 on San Miguel had relatedness values suggesting they were unrelated (-0.20 and -0.38, respectively), although the high overlap among San Miguel animals reduces the confidence of this determination. Changes for the 2003 season include a new pairing with 60921, formed by exchanging males with 92804. 60921 and 57150, newly mated for the 2003 - 2003 season, were tracked together in 1999, but were thought at the time to be siblings due to proximity of the sites where they were trapped as pups in 1998. Results of genetic testing (Gray et al. 2001) showed that these 2 animals are likely not siblings.

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

Year	Adults			Pups				Total Captive
	F	M	Total	F	M	Total	Died	
2000	10	4	14*	1	1	2	0	16
2001	11	5	16	0	5	5	1	20
2002	10	10	20	2	6	8	0	28

*Founding population

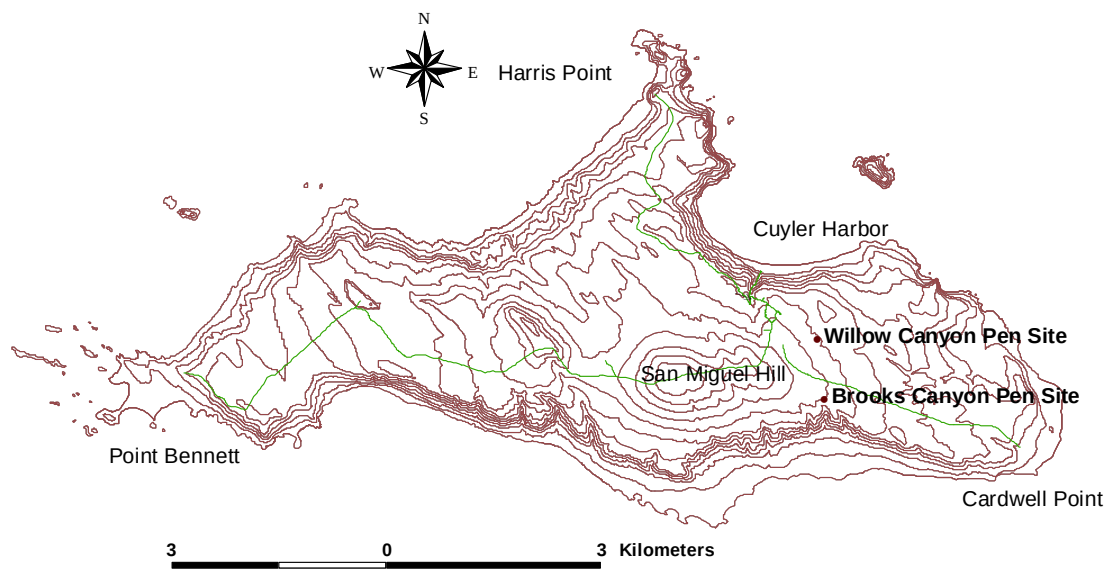


Figure 2. Location of island fox captive breeding facilities, San Miguel Island.

Breeding of Individual Pairs

90D1A (F) and 44829 (M) produced a litter of 3 pups (2 male, 1 female) in 2002, to bring their 3-year total number of offspring to 8 pups (6 M, 2F). Whelping was believed to have occurred the second week in April.

92C32 (F) and 7574A (M) produced a litter of 3 pups (2 males, 1 female) in 2002. This is the second litter for the pair, giving them a 2-year total production of 4 males and 1 female.

60921 (F) and 85D02 (M) exhibited strong breeding behavior up to and including mounting and thrusting with no actual ties recorded or observed. Island staff believed the female to be pregnant although no litter was found. After failing to reproduce in 2002, 60921 was paired with 57150 for the 2002 - 2003 season.

7534A (F) and 83C24 (M) were paired for the first time this year and failed to produce a litter. The pair will remain together for 2002 - 2003.

Table 4. Island foxes in captive breeding facility on San Miguel Island.

Pen ¹	PitTag	Sex	Age ²	Born	Sire	Dam	Date Captured	Capture Area
M01	87F53	M	Pup	Captive	7574A	92C32		
	85764	F	Pup	Captive	44829	90D1A		
M03	7574A	M	4	Wild			5/14/99	Willow Canyon
	92C32	F	4	Wild			5/17/99	Willow Canyon
M07	44829	M	4	Wild			9/4/99	Willow Canyon
	90D1A	F	4	Wild			9/2/99	Willow Canyon
M09	83C24	M	1	Captive	44829	90D1A		
	7534A	F	10	Wild			9/4/99	Nidever Canyon
M11	E2677	F	4	Wild			9/11/99	Willow Canyon
	47B06	M	2	Captive	44829	90D1A		
M12	70C1D	M	1	Captive	44829	90D1A		
	B0B25	F	3	Wild			9/28/99	Nidever Canyon
M13	F6558	F	3	Wild			10/4/99	Green Mountain
	11F73	M	1	Captive	44829	90D1A		
M14	85D02	M	3	Wild			9/17/99	Cardwell
	60921	F	4	Wild			9/24/99	Green Mountain
M15	B0E36	M	Pup	Captive	7574A	92C32		
	B7E0A	F	Pup	Captive	47B06	E2677		
M17	11929	F	2	Captive	44829	90D1A		
	C7303	M	1	Captive	7574A	92C32		
M18	71071	F	3	Wild			8/23/99	Cardwell
	C4A16	M	1	Captive	7574A	92C32		
M19	92804	F	10	Wild			10/24/99	Willow Canyon
	57150	M	4	Wild			10/4/99	Green Mountain
M20	E270B	M	Pup	Captive	44829	90D1A		
	B4E60	M	Pup	Captive	44829	90D1A		
M21	13212	M	Pup	Captive	47B06	E2677		
	66C6E	M	Pup	Captive	47B06	E2677		

¹Pens M01 - M11 are at Willow Canyon site; pens M12 - M21 are at Brooks Canyon site.

²in years, as of fall 2002

E2677 (F) and 47B06 (M) were paired for the first time in 2001 and failed to produce a litter. In 2002, the pair produced a litter of 3 (2 male, 1 female) and were caught on tape in a copulatory tie on February 11th. Whelping is thought to have occurred around April 11 - 19th.

B0B25 (F) and 70C1D (M) were paired for the first time this year and failed to produce a litter. Some breeding behavior was observed. The pair will remain together for 2002 - 2003.

F6558 (F) and 11F73 (M) were paired for the first time this year and failed to produce a litter. The pair will remain together for 2002 - 2003.

11929 (F) and C7303 (M) were paired for the first time this year and failed to produce a litter. The pair will remain together for 2002 - 2003.

71071 (F) and C4A16 (M) were paired for the first time this year and failed to produce a litter. The pair will remain together for 2002 - 2003.

92804 (F) and 57150 (M) were paired the first time this year and failed to produce a litter. 57150 was paired with 60921 for 2002 - 2003 because there is a possibility they were wild mates, and 60921 has failed to produce a litter despite being paired for 3 years.

Table 5. Reproductive success of captive San Miguel Island foxes, 2001-2002 breeding season.

Pen	PitTag	Sex	Age ¹	Paired	Result	Pups	Birth Date	Total Litters/Pups
M03	92C32 7574A	F M	3 3	7/16/99	Litter	2M	April, 2002	2/4
M07	90D1A 44829	F M	3 3	9/4/99	Litter	2M,1F	April, 2002	3/8
M09	7534A 83C24	F M	>10 1	9/17/01	No Litter			
M11	47B06 E2677	M F	2 4	10/26/00	Litter	2M,1F	April, 2002	1/3
M12	70C1D B0B25	M F	1 3	10/14/01	No Litter			
M13	11F73 F6558	M F	1 4	10/14/01	No Litter			
M14	85D02 60921	M F	4 4	9/4/99	No Litter			
M17	C7303 11929	M F	1 2	10/15/01	No Litter			
M18	C4A16 71017	M F	1 3	10/15/01	No Litter			
M19	57150 92804	M F	4 >10	9/17/01	No Litter			

¹in years, as of spring 2002

Wild Fox Population

The remaining wild fox on San Miguel, female 85619, remained wild in 2002. Both her continued reluctance to go into a box trap and the lack of an available male as potential mate in the captive population helped insure her current status. Although her radiocollar no longer transmits, there is frequent evidence of her presence in the form of scat and tracks, and remote cameras continue to show no other foxes on the island. The current plan is to try trapping in spring or summer 2003 for captive mating with a 2002 - born male.

Health/Medical

Veterinary examinations on San Miguel foxes were conducted by project veterinarian Mark Willett, DVM, in July 2002. Routine general physical examinations were performed in a nose to tail fashion, and otoscopic examinations were performed as well. Blood samples were obtained from all animals for complete blood chemistry analysis.

Foxes examined were generally in good health. There is a conspicuous absence of ectoparasites in the San Miguel foxes, compared to Santa Rosa foxes, and there is very little problem with crusty eyes.

Captive foxes on San Miguel Island have 3 parasites which have the potential to pose significant health problems: *Angiocaulus*, *Spirocerca*, and *Uncinaria*. Hookworm is a potential concern because hookworms feeding on the mucosa of the small intestine basically cause hemorrhaging and loss of blood through the intestinal tract, resulting in anemia. Bloody scats have been noted in many of the San Miguel pens. On the other hand, *Uncinaria stenocephala* is relatively innocuous as far as hookworms go, especially compared with *Ancylostoma caninum* (Georgi and Georgi 1991). High incidence of *Uncinaria* spp. has been associated with mortality of fur seal (*Callorhinus ursinus*) and California sea lion (*Zalophus californianus*) pups on San Miguel Island (Lyons et al. 1997).

Angiocaulus is not found in foxes from other islands (L. Munson, UC Davis, unpubl. data). Whereas the pathogenicity of *Angiocaulus* is largely unknown, necropsy of a San Miguel island fox indicated that *Angiocaulus* had caused extensive pulmonary granulomas and was present in heart blood. If such foxes were treated with an anthelmintic which crossed into the bloodstream and killed the *Angiocaulus*, a fatal outcome might occur (Linda Munson, UC Davis, pers. comm.). Moreover, spirocerids may cause a break in the intestinal mucosa which would allow an anthelmintic to cross into the bloodstream. Thus, foxes with *Angiocaulus* or spirocerids have not been treated for hookworm.

Currently there is no plan to treat foxes for parasites, because there is no consensus among project veterinarians that animals should be treated, and a risk analysis is required to assess the risks of treatment versus the risk of infection. The risks of treating foxes with *Angiocaulus* or spirocerids are uncertain at this point. Moreover the benefits of treating *Uncinaria* - only foxes are not entirely clear; *Uncinaria* may be the least impactful of the hookworms, the bloody scat may be due to other factors, and there are no other clinical signs, such as anemia. On the other hand, *Uncinaria* is directly transmitted and will build up in the captive facilities.

Dr. Rex Sohn of the U. S. G. S. Biological Resource Division's Wildlife Health Center is leading a parasite risk assessment for captive island foxes. To thoroughly quantify parasite loads in captive island foxes for the risk assessment, collection of fecal samples for parasite assay began in December 2002. Results and recommendations from this survey will be presented at the 2003 Island Fox Working Group meeting.

All adult foxes in captivity on San Miguel received both the initial and booster doses of CDV vaccine (Merial Ltd., Athens, GA) during vet examinations in summer 2002. The vaccine is a Canary Pox vectored recombinant canine distemper virus used successfully on Santa Catalina island foxes (Kohlmann et al. 2003).

Santa Rosa Island Captive Breeding Facility

Breeding Success

During 2002, the Santa Rosa captive population grew from 32 to 45 foxes with the birth of 13 pups (4 males, 9 females) in captivity (Tables 6 and 7). Six of 12 pairings (50%) produced a litter in 2002 (Table 8). Two of the 6 unsuccessful pairs were together for the second year. The other 4 pairs were together for the first time and consisted of first and second -year animals.

In October, pairings were made for the 2002 - 2003 breeding season. There are 16 pairs for the upcoming breeding season, and 13 unmated females. Currently the facility is at maximum capacity and if releases are not possible in 2003, facilities will need to be expanded or other arrangements must be made.

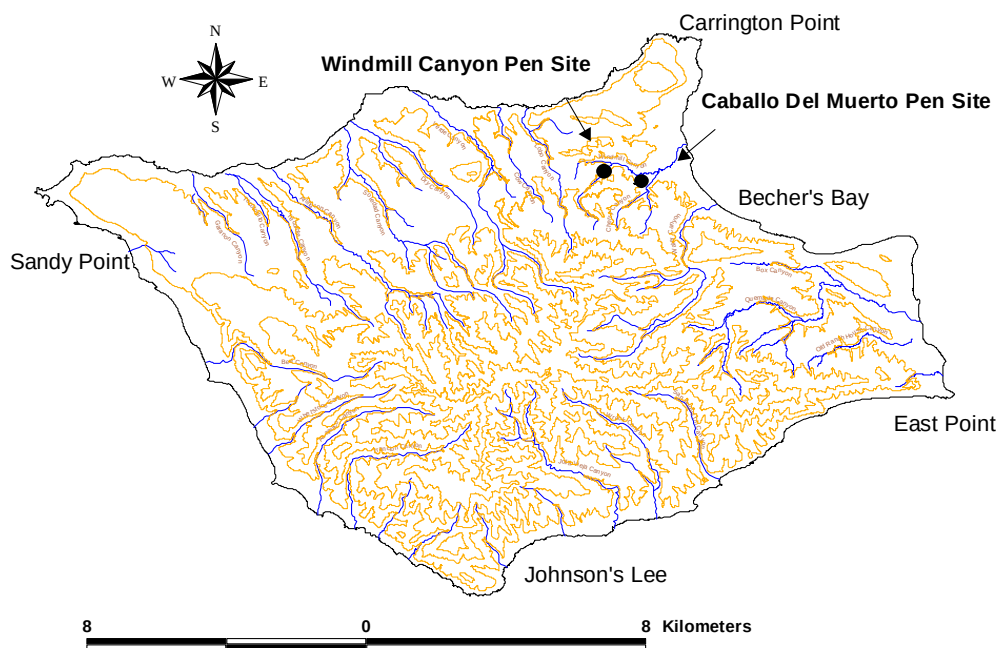


Figure 3. Location of island fox captive breeding facilities, Santa Rosa Island.

Breeding of Individual Pairs

1612C (F) and D3D76 (M) were paired for the first time in 2002 and produced a litter of 2 pups, both female. There is a strong probability that D3D76 was her original wild mate and thus the sire of 24108 (F).

F4A18 (F) and F0223 (M) produced 1 female pup in 2002 bringing their 3 -year total to 8 pups (6F, 2M). The pair showed strong compatibility when first introduced and F0223 is most likely the parent off the 2000 pups. This pair was selected as possible release animals for the initial reintroduction. Whelping is thought to have occurred around 15 April.

Table 6. Growth of captive island fox population, Santa Rosa Island.

Year	Adults			Pups				Total Captive
	F	M	Total	F	M	Total	Died	
2000	8	4	12 ¹	5 ²	5 ²	10	0	22
2001	14	9	23	7	3	10	1	32
2002	20	12	32	9	4	13	0	45

¹Founding population

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

37C61 (F) and 37E00 (M) failed to produce a litter for the second year in a row. The pair does exhibit some level of compatibility and because they are young animals will be left together for one more year. If they fail to reproduce in 2003 they will be split up.

10030 (F) and 70518 (M) produced 3 pups in 2002 (2M, 1F) for a 2-year total of 5 pups (3M, 2F). 70518 is a captive-born male paired with an older female. This pair showed strong compatibility and was often observed resting with each other. This pair was also selected as possible release animals for the initial reintroduction. Whelping is thought to have occurred around 15 April.

D187A (F) and 0654E (M) produced 2 female pups in 2002 for a 2-year total of 4 females. 0654E is a captive-born male mated with an older female.

95B34 (F) and 84F28 (M) produced 2 pups (1M, 1F) in 2002 for a 2-year total of 3 pups (1M, 2F). 84F28 is a captive-born male mated with an older female. Whelping is thought to have occurred the second week in April.

53315 (F) and A045A (M) failed to produce a litter in 2002, as well as in 2001. A045A is a captive-born male mated with an older female. The compatibility of this pair is unclear. They have been observed resting curled together, but also separately. If the pair does not produce a litter in 2003, they will be split up for the following breeding season.

3512D (F) and 73D0D (M) produced 3 pups (1M, 2F) in 2002 for a 2-year total of 5 pups (2M, 3F). Whelping is thought to have occurred around 9-11 April.

53315 (F) and A045A (M) failed to produce a litter in 2002 as well as 2001. A045A is a captive-born male mated with an older female. The compatibility of this pair is also unclear. If the pair does not produce a litter in 2003, they will be split up for the following breeding season.

3512D (F) and 73D0D (M) produced 3 pups (1M, 2F) in 2002 for a 2-year total of 5 pups (2M, 3F). Whelping is thought to have occurred around 9-11 April.

2410E (F) and B4B2B (M) failed to produce a litter in 2002. The male is a first-year captive male mated with a second-year captive-born female. This pair remains together for 2003.

E5100 (F) and F3D2F (M) failed to produce a litter in 2002. This is a first-year pair and will remain together for 2003.

96C28 (F) and 75125 (M) failed to produce a litter in 2002. This is a first-year pair and will remain together for 2003.

13C24 (F) and B067E (M) failed to produce a litter in 2002. This is a first-year pair and will remain together for 2003.

Health/Medical

Captive Santa Rosa Island foxes received veterinary examinations from project veterinarian Mark Willet, DVM, in August and September of 2002. Routine general physical examinations were performed in a nose to tail fashion, and otoscopic examinations were performed as well. Blood samples were obtained from all animals for complete blood chemistry analysis.

Foxes examined were in generally good or excellent condition, with a few exceptions. During the first day of examinations 2 foxes required treatment at the island's vet facility. Male F3D2F required a purse suture for a prolapsed rectum which developed during capture. The fox required

extended treatment at the vet facility, during which he was fed a soft fibrous diet. After 2 weeks without further prolapsing or additional health problems he was returned to the pen and reunited with his mate. There has been no further evidence of prolapse. Female 96C28 had a head wound requiring aggressive cleaning and stitches. The condition of her scalp improved dramatically after a week of antibiotic treatment, and she was then transferred to a quarantine pen until infection was ruled out. Within 2 weeks of being removed from her pen her head had healed, although there were still pockets of fluid under her scalp. It now appears that her condition is chronic, and appropriate treatment will be reassessed after the 2003 breeding season.

Foxes on Santa Rosa have more problems with ectoparasites (fleas and ticks) than do San Miguel foxes. All foxes were treated with Frontline (Merial Ltd., Athens, GA) during 2002 vet exams. All adult foxes with the exception of E5100 and F3D2F received both the initial and booster CDV vaccinations. No pups were vaccinated.

Table 7. Island foxes in captive breeding facility on Santa Rosa Island.

Pen	PitTag	Sex	Age	Born	Sire	Dam	Capture Date	Capture Area
R01	2571A	F	Pup	Captive	0654E	D187A		
	10445	F	1	Captive	70518	10030		
	4A7105	F	Pup	Captive	0654E	D187A		
R02	D187A	F	AC - 4	Wild			4/5/00	Smith Highway
	0654E	M	2	Captive		A7015		
R03	2410E	F	2	Captive		1612C		
	B4B2B	M	1	Captive	F0223	F4A18		
R04	60B1D	F	1	Captive	84F28	95B34		
	53723	M	Pup	Captive	73D0D	3512D		
R05	F0223	M	AC - 4	Wild			4/6/00	Smith Highway
	F4A18	F	AC - 3	Wild			3/29/00	Smith Highway
	95906	F	Pup		F0223	F4A18		
R06	37C61	F	2	Captive		F4A18		
	37E00	M	2	Wild			9/9/00	Skunk Point
R07	10030	F	AC - 4	Wild			4/5/00	Smith Highway
	70518	M	2	Captive		A7015		
	47304	F	Pup	Captive	70518	10030		
R08	B715F	F	Pup	Captive	D3D76	1612C		
	01460	F	Pup	Captive	D3D76	1612C		
R09	95B34	F	AC - 3	Wild			9/1/00	Torrey Pines
	84F28	M	2	Captive		F4A18		
	E3F0F	F	Pup	Captive	84F28	95B34		
R10	A045A	M	3	Captive		A7015		
	53313	F	AC - 3	Wild			4/3/00	Smith Highway
R11	3512D	F	AC - 4	Wild			11/5/00	Skunk Point
	73D0D	M	AC - 3	Wild			7/24/00	Torrey Pines
R12	07061	F	AC - 3	Wild			5/14/01	Windmill Canyon
	51E3E	M	Pup	Captive	70518	10030		
R13	34614	F	1	Captive	F0223	F4A18		
	C586D	F	1	Captive	F0223	F4A18		
R14	E5100	F	2	Captive		F4A18		
	F3D2F	M	1	Captive	70518	10030		
R15	96C28	F	1	Captive	0654E	D187A		

Pen	PitTag	Sex	Age	Born	Sire	Dam	Capture Date	Capture Area
	75125	M	1	Captive	73D0D	3512D		
R16	13C24	F	2	Captive		F4A18		
	B067E	M	AC-4	Wild			3/26/00	Smith Highway
R17	25D54	F	Pup	Captive	73D0D	3512D		
	63F2A	F	Pup	Captive	73D0D	3512D		
	E6D1E	F	Pup	Captive	73D0D	3512D		
R18	F3950	F	1	Captive	0654E	D187A		
	7792E	M	Pup	Captive	84F28	E3F03		
R19	D3D76	M	AC-3	Wild			3/24/00	Smith Highway
	1612C	F	AC-3	Wild			3/23/00	Smith Highway
R20	1271E	M	Pup	Captive	70518	10030		
	A180A	F	2	Wild			10/24/00	Skunk Point

¹Pens R01 - R10 are at Windmill Canyon site, pens R11 - R20 are at Caballo del Muerto site

²in years, as of fall 2002; for those animals in which birth year is not known, "AC" denotes age class: AC-1 = 7 mos. - 2 years, AC-2 = 2-3 years, AC-3 = 3-4 years, AC-4 = >4 years.

Table 8. Reproductive success of captive Santa Rosa Island foxes, 2001-2002 breeding season.

Pen	PitTag	Sex	Age	Paired	Result	Litter	Birth	Total Litters/Pups
R02	D187A	F	AC-3	10/19/00	Litter	2F		2/4
	0654E	M	2					
R03	2410E	F	1	10/26/01	No Litter			
	B4B2B	F	1					
R05	F0223	M	AC-3	10/19/00	Litter	1F		3/8
	F4A18	F	AC-3				4/3/01	
R06	37C61	F	2	10/19/00	No Litter			
	37E00	M	2					
R07	10030	F	AC-3	10/19/00	Litter	2M,1F		2/5
	70518	M	2					
R09	84F28	M	2	10/19/00	Litter	1M,1F		2/3
	95B34	F	AC-2					
R10	A045A	M	2	10/19/00	No Litter			
	53313	F	AC-3					
R11	73D0D	M	AC-2	11/5/00	Litter	1M,2F		2/5
	3512D	F	AC-3					
R14	F3D2F	M	1	10/11/01	No Litter			
	E5100	F	2					
R15	75125	M	1	10/29/01	No Litter			
	96C28	F	1					
R16	B067E	M	AC-3	10/12/01	No Litter			
	13C24	F	2					
R19	D3D76	M	AC-3	10/12/01	Litter	2F		1/2
	1612C	F	AC-3					

²in years, as of spring 2002; for those animals in which birth year is not known, "AC" denotes age class: AC-1 = 7 mos. - 2 years, AC-2 = 2-3 years, AC-3 = 3-4 years, AC-4 = >4 years.

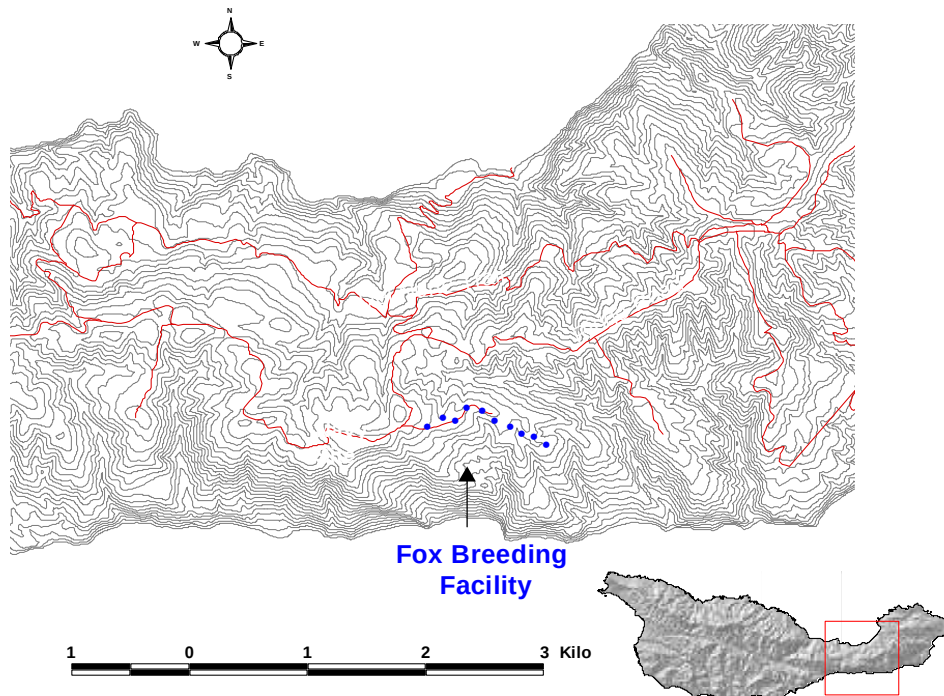


Figure 4. Location of island fox captive breeding facilities, Santa Cruz Island.

Santa Cruz Island Captive Breeding Facility

The Santa Cruz Island facility was constructed in February 2002 and consists of 10 pens spread along Renegade Ridge (Fig. 4). There are currently 10 pairs or 20 foxes in captivity on Santa Cruz Island (Table 9). Female foxes were brought in after mating in winter 2002 and 1 of those gave birth to a litter of 5 pups (4M, 1F). Additional foxes brought in during the summer were paired with 2 of the captive pups for the 2003 breeding season.

Three of the male pups (E0143, C0025, and 7142B) from pen C6 were released on December 5th, 2002. E0143 was found dead on 12/17/02, and C0025 was found dead on 12/21/02. Both carcasses showed signs of golden eagle predation (Newman et al. 2003). 7142B survived the initial release stage and remains active in the wild.

The Santa Cruz facility is currently at capacity. Because a wild island fox population still exists on the island, expansion of the facility depends on the trend in survival for wild foxes. If the wild population remains stable or grows then fewer captive foxes will be needed for the augmentation stage of recovery. If the wild population declines then a more aggressive captive breeding program would become necessary to insure an adequate number of reintroduction candidates.

Construction of Santa Cruz Facility

Ten pens were built on Santa Cruz Island in February 2002 using volunteers and Park personnel. Most pens are rectangular in shape and are constructed of 6' X 10' chain-link panels with 1 ¼" mesh. Pens have 10' X 10' roof panels to prevent fox escapes and aerial predation, and a buried groundskirt to prevent foxes from tunneling in or out. Shelter boxes are provided as well as natural cover, climbing structures, and tunnel systems. Hammocks and other resting perches are also provided.

Health/Medical

Captive Santa Cruz Island foxes received veterinary examinations from project veterinarian Mark Willet, DVM, in June 2002, following the same protocols that are implemented on San Miguel and Santa Rosa Islands. Routine general physical examinations were performed in a nose to tail fashion, and otoscopic examinations were performed as well. Blood samples were obtained from all animals for complete blood chemistry analysis. Foxes were generally in good or excellent health, although all required treatment for ectoparasites. All captive adult animals on Santa Cruz received initial and booster CDV vaccinations. One female fox (16C30) was brought in injured from the wild and required the amputation of a toe. The fox recovered and was placed into the captive population and paired with one of the pups born in pen C6.

Table 9. Island foxes in captive breeding facility on Santa Cruz Island.

Pen	PitTag	Sex	Age ¹	Born	Sire	Dam	Capture Date	Capture Area
C1	30B2D	F	AC - 2	Wild			2/27/02	Pozo Divide
	A4628	M	AC - 3	Wild			3/11/02	Cebada Canyon
C2	D2C13	F	AC - 1	Wild			2/27/02	Eagle Mountain
	A6D41	M	1	Wild			3/3/02	Sauces Canyon
C3	0786F	F	AC - 3	Wild			2/28/02	Mielquieres
	1415A	M	AC - 1	Wild			3/3/02	China Pines
C4	C5D0E	F	AC - 1	Wild			12/4/02	Isthmus
	B506A	M	AC - 1	Wild			12/4/02	Isthmus
C5	72901	F	AC - 1	Wild			2/27/02	Prisoner's Canyon
	36172	M	AC - 1	Wild			2/27/02	Prisoner's Canyon
C6	86F17	F	AC - 1	Wild			3/10/02	Pozo Canyon
	86B1A	M	AC - 1	Wild			2/27/02	Pozo Canyon
C7	D2210	F	1	Wild			3/11/02	Cebada Canyon
	45411	M	1	Wild			3/1/02	China Pines
C8	16C30	F	AC - 1	Wild			6/4/02	Navy Site
	D0926	M	1	Captive	86B1A	86F17		

C9	87035	F	AC - 3	Wild		12/4/02	Coches Prietos Canyon
	1783E	M	AC - 4	Wild		12/4/02	Coches Preietos Canyon
C10	C002B	M	1	Wild		10/4/02	Navy Road
	73863	F	1	Captive	86B1A 86F17		

¹in years, as of fall 2002; for those animals in which birth year is not known, "AC" denotes age class:
AC - 1 = 7 mos. – 2 years, AC - 2 = 2 - 3 years, AC - 3 = 3 - 4 years, AC - 4 = >4 years.

Removal of Golden Eagles

Staff from the Santa Cruz Predatory Bird Research Group continued their efforts to remove golden eagles via bownet or other live - capture method in 2002. Bownet trapping met with little success. An adult male from the Coche Point breeding pair was captured in May 2002. The adult female was not captured via bownet or nest - net trapping methods, and so 2 chicks were pulled from the nest and fostered into mainland golden eagle nests.

Because a number of birds remained that were deemed unlikely to be caught with existing methodology, the Park attempted 2 golden eagle net - gunning operations in 2002. During the first net - gunning operation (14 - 24 June), 3 golden eagles were observed, and 1 was pursued, but none were captured. Weather (fog and wind) prevented operations during a portion of the week, and the aircraft had inadequate power to keep up with birds when going upwind. The second operation was conducted 15 - 22 October with more field observers, a more powerful aircraft, and with less wind and fog. Golden eagles were sighted and pursued on 4 of the 8 operational days. No eagles were captured. Wind, thermals and topography allowed eagles to rest by soaring and gliding, and pursued eagles outmaneuvered the aircraft, or were grounded in areas that were unsuitable for deploying the net - gun. Results indicate that net - gunning is not an appropriate technique for capturing eagles on Santa Cruz Island, due to unsuitable terrain and dense vegetation.

By the end of 2002 a handful of eagles were thought to remain on Santa Cruz Island. Additionally, 5 eagles were observed on Santa Rosa Island during a helicopter survey for deer and elk in December 2002. Investigation by Bird Group staff in early 2003 confirmed 2 breeding pairs of golden eagles on Santa Rosa Island, both observed incubating in February. Golden eagles were not previously known to breed on Santa Rosa Island, but the existence of alternate nests in each territory suggests successful breeding on Santa Cruz Island in 2001 or 2002.

In early 2003 golden eagles were observed feeding on carrion left for reintroduced juvenile bald eagles on Santa Cruz Island. Establishment of a bownet trapping site at the location resulted in the capture of 6 golden eagles within a 1 - month period. Three eagles are thought to remain on Santa Cruz, in addition to the 4 breeding adults on Santa Rosa Island.

Monitoring of Wild Foxes

There are no wild foxes on Santa Rosa Island and only 1 wild fox on San Miguel Island. However, 80-100 foxes exist in the wild on Santa Cruz Island, and monitoring of this population is required both to assess the population's status and trend, and to identify rate and sources of mortality for island foxes. Such information will determine if golden eagle removal is an effective recovery action. If mortality levels are acceptable (that is, if modeling indicates the rates would result in an increasing fox population), then release of captive foxes back into the wild may begin.

Accordingly, the Institute for Wildlife Studies is currently conducting a study of the wild fox population on Santa Cruz Island, with funding from The Nature Conservancy (Dennis et al. 2001a, 2001b, 2002a, 2002b; Newman et al. 2002a, 2002b, 2002c, 2003). To investigate sources and rates of mortality, 20-25 radiocollared foxes are monitored for survival and general area of use. Information on population status and trend is derived from annual transect-trapping on the island.

Eagle Predation and Island Fox Mortality

Since December 2000, 19 radiocollared foxes have died, and golden eagle predation was identified as the cause of mortality for 16 of the 19 foxes. Nine radiocollared foxes died in the first year of the study, all but 1 from predation. Seven foxes died in the second year of the study, with predation being identified as mortality cause for 5 of those foxes. Two of the latest predation-caused mortalities occurred in December 2002, when 2 of 3 captive-born pups released in early December were killed by golden eagles. Previous to that, the last predation-caused mortality occurred in April 2002.

The mortality data can be used to estimate annual survivorship of island foxes using the non-parametric Kaplan-Meier procedure with staggered entry (Pollock et al. 1989). Under this procedure, survivorship starts out at 100% and declines with each successive mortality. Annual survivorship for 2001, the first year of the study, was 61% (95% confidence interval = 57-66) and in 2002 was 70% (CI = 67-74). In comparison, fox survivorship in 1993-1994 on Santa Cruz Island, prior to the decline, was over 80%, but declined to 39% the following year due to eagle predation (Roemer et al. 2001a). Island fox survivorship on San Miguel Island in 1998-1999, prior to bringing foxes into captivity, was 12% (Coonan et al. in review). Thus, current survivorship on Santa Cruz Island is greater than that recorded during the island fox population decline.

Fox survivorship improved from 2001 to 2002, perhaps due to the beneficial effects of eagle removal. However, an annual survivorship of at least 80% is necessary for recovery of island fox populations (Roemer et al. 2001b). Demographic modeling shows that a Santa Cruz island fox population with 80% annual survivorship has a >99% chance of recovering to carrying capacity, but a population with 70% survivorship never increases beyond the current low level of 75 foxes, and has a 50% chance of going extinct (T. Coonan, National Park Service, unpublished data).

Population Status and Trend

Results from island-wide trapping efforts in 2001 and 2001 suggest that the Santa Cruz Island fox wild population may be stable, but not increasing. Island fox trapping success in 2002 (14.6%) was nearly identical to that in 2001 (17.7%), and similar number of individuals were caught in 2002 (70 adults, 27 pups) as in 2001 (75 adults, 32 pups) (Dennis et al. 2002b, Newman et al. 2003).

Budget

A variety of funding sources supported island fox recovery actions implemented at Channel Islands National Park in fiscal year 2002 (Table 10). Captive breeding costs totaled approximately \$365,000, and included the costs of island fox care on 3 islands, as well as construction and development of the Santa Cruz Island facility. Settlement monies from environmental contaminant settlements held by National Park Foundation comprised the largest single funding source, providing about 27% of the total effort. National Park Service funds accounted for 50% of the effort, divided among 20% Fee Demonstration funds, Channel Islands National Park base funds, and the last year of a 3-year Natural Resource Preservation Program funding project. The Nature Conservancy continued its support of the wild fox survivorship project on Santa Cruz Island, funded the costs of fencing for the new Santa Cruz Island fox captive breeding facility, and is funding fox caretaking for that facility.

Table 10. Costs and funding sources for island fox recovery actions, fiscal year 2002 (1 October 2001 to 30 September 2002).

Fiscal Year 2002	NPF Settlement	NPS 20% Fee Demo	NPS NRPP	NPS Parkbase	TNC	Total
Program Coordinator				82,724		82,724
Captive Breeding						
Personnel	36,992	6,429	82,000	65,000	48,000	238,421
Island per diem	5,855	12,026				17,881
SCI Pen construction	15,000				22,000	37,000
Flights		32,560				32,560
Fox food	18,113					18,113
Supplies/equipment		2,600				2,600
Vet care		6,000				6,000
Vet tests		5,202				5,202
Vet supplies		7,440				7,440
Total Captive Breeding	75,960	72,257	82,000	65,000	70,000	365,217
Eagle Removal	110,481					110,481
Eagle Net-gun Ops		50,000		10,000		60,000
SCI Fox Monitoring					100,000	100,000
Island Fox Meeting	10,000					10,000
TOTAL	196,441	122,257	82,000	157,724	170,000	728,422

Future Costs

Estimated costs for island fox recovery actions in fiscal year 2003 are presented in Table 11. Personnel costs are higher due to the addition of a relief biological technician for fox care, and the planned hire of a biologist to oversee the program and initiate monitoring of released foxes. Available funding sources include remaining monies from the 20% Fee Demonstration project and the first year of a new Natural Resource Preservation Program project.

Table 11. Estimated costs and funding sources for island fox recovery actions, fiscal year 2003.

Fiscal Year 2003	NPS 20% Fee Demo	NPS NRPP	NPS Parkbase	TNC	Total
Program Coordinator			86,447		86,447
Captive Breeding					
Personnel		174,377	65,000	48,000	287,377
Island per diem		25,828			25,828
Flights		33,863			33,863
Fox food	28,257				28,257
SMI foxpital	22,000				22,000
Supplies/equipment	14,200				14,200
Vet care		12,060			12,060
Vet tests		10,600			10,600
Vet supplies		1,040			1,040
Total Captive Breeding	64,457	257,768	0	48,000	435,225
Eagle Removal	115,000			25,000	140,000
SCI Fox Monitoring				100,000	100,000
Island Fox Meeting	10,000				10,000
TOTAL	189,457	257,768	86,447	173,000	771,672

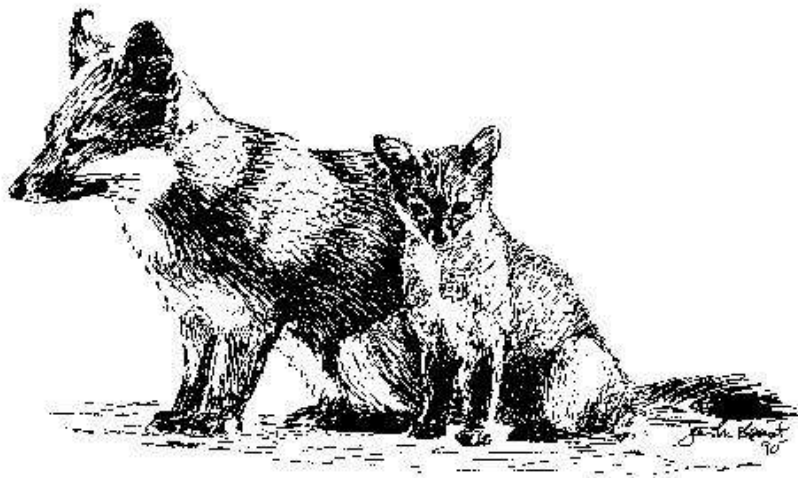
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Appendix A Findings of the Island Fox Conservation Working Group

**FINDINGS OF THE
ISLAND FOX CONSERVATION WORKING GROUP
JUNE 25-27, 2002
VENTURA, CALIFORNIA**



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SUMMARY:

From June 25-27, 2002, the Island Fox Conservation Working Group conducted its fourth annual meeting in Ventura, California. The working group is a loose affiliation of agency, conservancy, zoo, non-profit and academic representatives concerned with conservation of the island fox (*Urocyon littoralis*). The group meets annually to exchange information about island fox status and recovery actions, to evaluate recovery efforts, and to identify management concerns and research needs.

According to the most recent information, 5 of the 6 island fox subspecies are in decline or have declined catastrophically. Current threats to island foxes are predation by golden eagles on the northern Channel Islands; canine distemper virus on all islands, but especially on Santa Catalina, site of a recent outbreak and with a source of domestic dogs; and the genetic and demographic consequences of small population size, for the three northern subspecies.

On San Miguel and Santa Rosa Islands, all island foxes but 1 (an adult female on San Miguel) are in captivity. The San Miguel captive population has grown from 14 foxes in 1999 to 28 foxes, but only three of 10 pairs have successively bred. On Santa Rosa, where there are no foxes left in the wild, the captive population has grown from 16 animals in 2000 to 45 foxes. The Santa Rosa captive population is nearing capacity and production levels, and initial releases back into the wild could occur this fall, if golden eagle predation is sufficiently mitigated.

On Santa Cruz Island, the current wild population is estimated to be 50-60 foxes. Despite removal of 22 of the 25 known golden eagles from that island since 1999, an island fox radiotelemetry study documented the deaths due to eagle predation of 11 of 35 radiocollared foxes. This continued eagle predation coupled with the low wild island fox population size prompted the National Park Service and The Nature Conservancy to begin island fox captive breeding on Santa Cruz Island in 2002. There are currently 18 foxes in captivity on Santa Cruz Island. Three golden eagles remain on the island, and efforts to remove them will continue.

San Nicolas Island continues to have the only stable and dense population of island foxes, although there are still concerns about the lack of genetic variation in that population, and its vulnerability to canine diseases. Antibodies to canine distemper virus were detected in blood samples from San Nicolas island foxes tested in 2001, although there was no associated population decline, nor did any foxes show clinical signs of disease. The island fox population on Santa Catalina Island, which was decimated by canine distemper in 1999-2000, is being augmented by both a wild fox translocation program and a captive breeding program funded by the Santa Catalina Island Conservancy and implemented by the Institute for Wildlife Studies. Both wild and captive foxes have been vaccinated against canine distemper virus with an experimental recombinant vaccine, which has been demonstrated to be safe and effective.

On San Clemente Island foxes are in decline, perhaps due in part to loggerhead shrike predator control measures. The group recommended that the cause of the decline be investigated via a radiotelemetry study, and that impacts to foxes from predator control activities and rat eradication cease. The conservation agreement currently being developed between the U.S. Navy and the U.S. Fish and Wildlife Service is an appropriate vehicle for such actions.

Disease and parasites continue to be of concern for captive foxes. The San Miguel population in particular has high infection rates of unique parasites. The USGS-Biological Resources Division's Wildlife Health Center is currently conducting a risk assessment for treating parasites in captive island foxes. Wild and captive foxes on Santa Catalina Island have been vaccinated against canine distemper virus with an experimental vaccine, and it is recommended that all captive island foxes be vaccinated against canine distemper virus.

The mainland zoo population of island foxes, which are all from the San Clemente subspecies, is growing, and is of great importance to furthering conservation efforts for the species as a whole.

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MEETING PURPOSE:

The purpose of the annual meeting is three-fold:

- To exchange information and updates regarding island fox status, management actions, and research on all islands
- To provide an annual technical review of current recovery efforts
- To identify island fox management and research needs, and to foster cooperative efforts among the different agencies and landowners

The Island Fox Conservation Working Group is a loose affiliation of public agency representatives, landowners, conservancies, zoological institutions, non-profits and academics concerned about conservation efforts for the island fox. The island fox is in decline on four and perhaps as many as 5 of the 6 Channel Islands on which it occurs. The species is listed as Threatened by the State of California and was recently proposed to be Federally listed as Endangered. Because there is, as yet, no coordinated recovery program for this species, the working group serves as a forum for information exchange and evaluation of current recovery efforts. The working group communicates primarily through an annual meeting, but also via email and telephone conference calls. The group further divides into subject matter groups to tackle most issues. The individual working groups for this year's meeting were policy and education, management of wild populations, management of captive populations, island fox husbandry, and veterinary issues.

BACKGROUND AND ISSUES:

Island fox populations on the three northern islands (San Miguel, Santa Rosa and Santa Cruz) declined catastrophically from 1995 to 1999, and predation by golden eagles was identified as the primary cause of the decline. A group of experts convened by the National Park Service in 1999 concluded that island foxes were threatened with extinction on San Miguel and Santa Rosa Islands, and so identified the need to remove golden eagles from the northern Channel Islands and to begin a captive breeding program for island foxes on those islands. The Park began implementing emergency recovery actions in summer 1999.

Captive breeding of island foxes began on San Miguel Island in 1999, on Santa Rosa Island in 2000, and on Santa Cruz Island in 2002.

Golden eagle predation on island foxes on the northern Channel Islands is facilitated by the existence of an extensive prey base of feral pigs on Santa Cruz Island. Moreover, the more diurnal nature of the island fox, compared to other fox species, and the conversion of native shrubland to alien annual grassland have increased the vulnerability of island foxes to eagle predation. Breeding bald eagles, which are highly territorial and may have deterred golden eagles from using the islands, bred on the islands historically but have been missing from the northern Channel Islands since the 1950's due to the effects of organochlorine pesticides and direct persecution by humans. Long-term solutions to the problem of golden eagle predation require the removal of feral pigs from Santa Cruz Island, and the restoration of bald eagles to the northern Channel Islands. In conjunction with The Nature Conservancy, the NPS has developed a plan to remove pigs from Santa Cruz Island, and removal efforts will begin in 2003. Additionally, the feasibility of reintroducing bald eagles to the northern Channel Islands is being tested via an experimental release of eagles on Santa Cruz Island, funded by the recent settlement of the Montrose Chemical Company contaminant case.

The island fox population on Santa Catalina Island in the southern Channel Islands declined precipitously from 1999 to 2000, and research indicated that an epidemic of canine distemper virus was the cause. The epidemic decimated island fox populations on the eastern 80% of the island. In conjunction with the Catalina Island Conservancy, the Institute for Wildlife Studies began a field vaccination program for wild foxes on Catalina, has recently relocated foxes from the west end to the east end, and has started a captive breeding program as well. The recent canine distemper outbreak on Catalina underscores the vulnerability of island foxes to canine and other diseases.

Currently, there are four island fox captive breeding facilities on the Channel Islands, and island foxes are held in captivity at 5 mainland zoological institutions. Because island foxes were never bred in captivity prior to establishment of these programs, quick development of appropriate husbandry methods has been a priority. Much of the island fox's reproductive physiology is still unknown, as are reasons for the relative lack of reproductive success in the San Miguel captive breeding program.

The influence of disease and parasites as island fox mortality factors remains a concern for all populations. Parasites are of particular concern on San Miguel Island.

The continued predation by golden eagles Santa Cruz island foxes remains the primary concern for foxes on the northern Channel Islands. In the southern islands, there are concerns about the effects of loggerhead shrike predator management activities on the San Clemente island fox.

STATUS OF EACH SUBSPECIES:

San Miguel Island

There are 28 foxes in captivity on San Miguel Island, and 1 left in the wild. A carcass found on Harris Point in March 2002 was thought to be that of the lone remaining wild animal, but recent sign, scat and photographic evidence from the western end of the island indicate that the lone wild fox, an adult female, is still alive. The 28 captive foxes include 13 of the 14 brought into captivity in 1999, and 15 pups born in captivity. Only three of 10 pairings in 2001-2002, and only 2 of the original four pairings, have produced litters. The results of recent genetic testing were used to separate a pair now thought to be related. The sex ratio of the pups born in captivity on San Miguel is skewed toward males. One older adult female fox died in captivity in December 2001, of unknown causes. Because the targeted captive population size is 40 animals, or 20 pairs, it will be several years before the San Miguel captive population is large enough to begin releasing foxes back into the wild.

Santa Rosa Island

There are currently no wild foxes on Santa Rosa Island, and there are 45 in captivity. Pup production on Santa Rosa continues to be good. A total of 13 pups were born in spring 2002, and 6 of 12 pairs produced litters. Of the 31 pups born since 2000, 20 have been female, and there will be 13 excess females in the captive population for the 2002-2003 breeding season. Given the good recruitment, some Santa Rosa captive foxes could be released in to the wild in fall 2002, if eagle predation is sufficiently mitigated.

Santa Cruz Island

By October 2001 several golden eagles remained on the island, and an island fox radiotelemetry study conducted by the Institute for Wildlife Studies indicated that eagle predation was still a factor for the population. Because of this, and because the wild population on Santa Cruz was estimated to be only 50-60 animals, the National Park Service and The Nature Conservancy decided to begin captive breeding of island foxes on Santa Cruz. Ten pens were built at a site on the Isthmus, and 12 foxes were brought into captivity in spring 2002. Among those animals were four known or suspected pairs, and 1 of those pairs gave birth to a litter of five pups in April 2002. Additional animals will be brought into captivity in summer 2002, to fill the captive breeding facility. Release into the wild will depend on removal of the remaining golden eagles. Thirteen of 35 radiocollared foxes died in the period from December 2001 through May 2002, and 10 of those foxes died from eagle predation. Annual survival for the first year was 63%, which is better than the 20% survival documented by Dr. Gary Roemer in 1994-95 on Frazier Point, but less than the approximately 80% survivorship needed to guarantee a stable or increasing fox population.

San Nicolas Island

Grace Smith of the U.S. Navy and Greg Schmidt of the Institute for Wildlife Studies reported that the island fox population on San Nicolas continues to be dense and stable. The islandwide estimate, based on mark-recapture estimates from grid trapping, is 435 foxes, and the population is skewed toward older foxes. As in 2000, 1 of the three trapping grids had a density of over 16 foxes/km², among the highest ever recorded for island foxes.

Twenty island fox blood samples from San Nicolas Island were tested for canine diseases. All were positive for canine parvovirus and 80% were positive for canine distemper virus. Given the recent distemper-caused population decline on Santa Catalina, the presence of antibodies to CDV in San Nicolas foxes is of concern. At this point, there is no evidence of a population decline or clinical signs in San Nicolas foxes.

Collision with vehicles has historically been an important fox mortality cause on San Nicolas, but implementation of reduced speed limits and installation of signs and other educational efforts have reduced its impact.

Santa Catalina Island

Dr. Steve Timm of the Institute for Wildlife Studies reported on recovery of the Santa Catalina island fox population following a canine distemper outbreak in 1999-2000. The Santa Catalina Island Conservancy is funding IWS to increase the wild fox population through translocation of individual foxes from the west end to the east end, and by augmentation from a captive breeding program. Additionally, IWS is vaccinating captive and wild foxes against canine distemper virus.

A total of 22 juveniles have been translocated from the west end to the east end, with good survivorship (80% for 2001 cohort; 100% for 2002 cohort). The captive breeding program, which comprises 12 breeding pens, produced 6 pups in spring 2001 and eight pups in spring 2002. There was considerable neonatal mortality each year. The first release of captive-born juvenile foxes occurred in fall 2001. The 6 pups were housed together in a large pen prior to release, and have all survived.

Vaccination with the experimental, recombinant canary pox vaccine appears to produce sufficient antibody response in foxes, and requires a booster 1 month after the initial vaccination.

San Clemente Island

Island foxes on San Clemente Island have been intensively monitored and managed as part of the U.S. Navy's predator management program for the endangered San Clemente loggerhead shrike. Greg Schmidt of the Institute for Wildlife Studies reported that three trapping grids have been monitored since 1988, 1 since 1999, and two since 2000. Island foxes are generally declining on San Clemente Island, but the reason is not clear.

Dr. Kelly Brock of the U.S. Navy reported on the factors that are possibly affecting San Clemente island foxes. Island foxes on San Clemente Island have been managed intensively in areas where loggerhead shrikes breed. In 1999, 15 island foxes were relocated to mainland zoos, and 13 were euthanized. In 1999 and 2000, some individual foxes were captured and held in captivity during shrike breeding season until after shrike nestlings fledged. The number of foxes held in captivity for this purpose was 77 in 1999, and 49 in 2000. Since 2000, foxes in shrike breeding territories have been shock-collared to prevent their access to shrike nests. There are about 50 shock-collared foxes in 2002, and a total of about 80 have been shock-collared since 2000. It is possible that such predator management activities have impacted the island fox population.

Island foxes may also be impacted by feral cat removal activities (trapping) and by black rat eradication (ingestion of rodenticide). The Navy has reduced the incidence of foxes being hit by vehicles through lowering speed limits and through education efforts.

The Navy is currently developing a candidate conservation agreement with the U.S. Fish and Wildlife Service to implement conservation measures for island foxes on San Clemente Island.

GOLDEN EAGLE REMOVAL:

Since 1999, 22 of 25 known golden eagles have been removed from Santa Cruz Island by the Santa Cruz Predatory Bird Research Group. The last birds removed were captured in May 2002, and comprised the adult male and two nestlings from a golden eagle nest near Coche Point. Prior to that, four eagles were removed in fall 2001. Golden eagles left on the island include the adult female from the Coche nest and two subadults which range over the island.

In June 2002 the NPS attempted a different method of eagle capture. Until that time, all trapping was by bow-net set over bait. In June NPS attempted a net-gunning capture operation, in which eagles would be spotted, pursued by helicopter and then captured via net-gun when they set down. The operation ran for 12 days. Eagles were sighted but were not captured, due to weather (fog) and lack of adequate power in the Bell Jet Ranger aircraft. Another operation will be attempted in the fall, when fog is not as prevalent, and with a different helicopter.

PATHOLOGY, DISEASE AND PARASITES:

Dr. Linda Munson of UC Davis reported results from her ongoing island fox pathology study. Of 141 foxes necropsied to date, 99 were intact. The following morbidity and mortality factors were identified:

- Emaciation (53/99): general nutritional condition is of concern, because the emaciation was not associated with dental attrition or underlying disease.
- Wounds, perhaps from intraspecies aggression during the breeding season, and cat trap wounds.
- Thyroid atrophy: 88% of necropsied foxes, from all islands. Thyroid function tests indicate little free thyroid hormone, no reserves and low thyroid stimulating hormone. Link to environmental toxins possible but unestablished.
- Ceruminous gland carcinomas (cancer) in ear canal. Three cases on Santa Catalina, where there is also high incidence of ear mites.
- Renal disease: amyloidosis (abnormal protein deposits) in 20 foxes.
- Canine distemper virus: confirmed on Santa Catalina; antibodies to CDV found in San Nicolas foxes but no death or clinical signs.

- Systemic mineralization: mineral deposition in tissues of San Clemente foxes, probably as a result of ingestion of Quintox rodenticide.

Specific parasites continue to be of concern for several island fox subspecies:

- *Spirocerca*: results in intestinal perforation and granulomas. Fox is definitive host; unique to gray and island foxes.
- *Angiocaulus* (lungworm): found only on San Miguel, results in lung granulomas.
- *Uncinaria* (hookworm): DNA fingerprinting indicates that the hookworm found in captive San Miguel foxes is not the same species as the hookworm which causes extensive neonatal mortality in California sea lions on that island.

Dr. Rex Sohn of the USGS-BRD Wildlife Health Center is leading an assessment of the risk associated with treating parasites in captive island foxes. Preliminary results from the first parasite treatment workshop calls for deferring treatment at this time, because captive foxes do not have clinical signs. Instead, good environmental controls are recommended, and thorough parasite surveys will be conducted on the captive populations.

GENETICS:

Melissa Gray of California State University, Los Angeles, recently conducted a genetic study of the captive fox populations on San Miguel and Santa Rosa Islands. She found that there had been a general loss of genetic variation in the populations since 1988, manifested by a reduction of alleles at some loci and a complete loss of polymorphism at others. There was a high inbreeding coefficient at three of eight San Miguel loci and seven of 14 on Santa Rosa. Relatedness values among foxes were calculated to determine if current pair members were related, and to guide future pairings. Accordingly, 1 pair on San Miguel was split up, as was 1 pair on Santa Rosa Island.

Dr. Robert Wayne of UCLA reported results from a recent investigation into variation in island fox genes that have fitness consequences, specifically genes for the major histocompatibility complex (MHC). San Nicolas foxes, which were previously found to be monomorphic at microsatellite loci, were found to have considerable heterozygosity at two MHC loci. On the other hand, the captive populations on San Miguel and Santa Rosa no longer possess some of the MHC alleles that were once present in the wild populations.

MAINLAND ZOO POPULATION:

Curator Alan Varsik of the Santa Barbara Zoo reported that the AZA Canid/Hyaenid Taxon Advisory Group (TAG) recommends that the captive island foxes currently held in mainland zoos be managed according to a population management plan (PMP) program. The mainland island foxes, all of them of the San Clemente subspecies, number 15 and are currently held at the Santa Barbara Zoo, the Lindsey Wildlife Museum, the California Living Museum, Utah's Hogle Zoo, and the Los Angeles Zoo. Five other institutions are interested in exhibiting island foxes. Captive pairs at the Santa Barbara Zoo produced litters in 2001 and 2002. The Santa Barbara Zoo, which manages the island fox studbook, recently published a husbandry manual for island foxes.

LEGAL STATUS:

In December 2001 the U.S. Fish and Wildlife Service proposed to list four island fox subspecies (San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina) as Endangered under the Federal Endangered Species Act. Following publication of such a proposed rule, the Service has 1 year to gather comment and make a final decision. Thus, a final rule for listing could appear as early as December 2002. However, the Service was not funded to work on the final rule in fiscal year 2002 (which ends September 30, 2002) and so publication of a final rule may occur some time after December 2002.

Dr. Gary Roemer of New Mexico State University, chair of the Island Fox Working Group of the IUCN's Canid Specialist Group, reported on the upcoming IUCN Canid Conservation Plan. The island fox section

of the Plan will recommend the whole species be listed as Endangered, and the individual island fox subspecies assigned to the following IUCN Red List Categories:

- San Miguel island fox Extinct in the Wild
- Santa Rosa island fox Extinct in the Wild
- Santa Cruz island fox Critically Endangered
- Santa Catalina island fox Critically Endangered
- San Clemente island fox Endangered
- San Nicolas island fox Vulnerable

The plan will contain the following action items for island fox conservation: enhance captive reproduction via female mate choice and semen banking; apply non-invasive techniques for monitoring the genetic health of wild populations; and implement a moratorium on trapping San Clemente island foxes as part of the loggerhead shrike recovery program.

FINDINGS:

Policy and Education

1. If the proposed island fox populations are listed, the FWS should consider managing the subspecies using this Working Group model rather than a smaller recovery team. The timing of a final listing decision should consider how to minimize impacts to ongoing recovery activities. If there is likely to be a hiatus of several months before required permits can be granted, then an autumn listing would have the least effect on recovery activities.
2. A consistent dog management policy, clearly explained to managers and visitors of all the islands, should be instituted. The primary object of this policy is to minimize the likelihood of disease transmission. All dogs coming to any of the islands should have evidence of current distemper vaccination. Movement back and forth from the mainland to the islands should be minimized.
3. The actions implemented by the U.S. Navy on San Clemente to minimize shrike and fox management conflicts are acknowledged. In light of apparent fox population declines, the additional steps outlined under “Management of Wild Fox Populations” are suggested.
4. There is a need to identify a location where past samples from island foxes can be stored and samples that are taken in the future can be sent and maintained. These samples, which could include whole blood, serum, tissues, and extracted DNA, must be properly and safely stored, and properly curated. The costs of storage and curation should be incorporated into the research budget. Electronic records of the samples should be generally available. Proposals for utilizing subsamples should be evaluated by a group that has wide representation in fox recovery efforts. General analysis on the species can be done on samples taken from the subspecies that is in mainland zoos.
5. There is a need to develop a consistent positive education message that conveys the complexity involved in the many steps of island fox recovery efforts. Zoo exhibitors have invaluable experience in developing these education materials, which can at the same time be tied to recent updates of events occurring on the Channel Islands. There will likely be a wave of publicity when the fox is officially designated an endangered species, and it would be worthwhile to have many pieces of the recovery effort well explained and illustrated at that time.

Management of Wild Island Fox Populations

1. The overriding threat to the three northern subspecies continues to be golden eagle predation. The effect of eagle predation, and the extent to which it can be minimized, will determine the success of recovery efforts. Eagle removal has been enormously successful, in that 22 of 25 known eagles have been removed from Santa Cruz Island, and none have returned. However, the three eagles that remain may still visit significant predation upon island foxes. The recent attempt at net-gunning should be repeated at a time of year with more favorable weather conditions, and after careful evaluation of the first net-gun operation. The recent lack of success in bownet trapping should also be evaluated. Because obtaining a permit for lethal removal will take considerable time, that process should be initiated.
2. Release of island foxes back into the wild on Santa Rosa Island is contingent upon a lack of eagles on that island. Eagle surveys should be conducted prior to release to determine presence or absence of eagles. Intensive post-release monitoring should be conducted for fox survivorship and eagle presence. If significant predation occurs, foxes may be brought back into captivity. To prevent attracting and supporting golden eagles, the current hunt for deer and elk on Santa Rosa should be managed so as to remove all carrion (gut piles) from the field.
3. The San Clemente subspecies appears to be in decline, but for unknown reasons. Further investigation of the San Clemente population is required to determine current mortality factors, island fox use of habitat, and the effect of loggerhead shrike predator removal activities on island foxes. A radiotelemetry study would be the appropriate investigative technique. Emphasis would then be on current population vital rates, as opposed to mere islandwide population size. Loggerhead shrike predator removal activities should be modified to avoid impacting island foxes, especially because shrikes appear to be recovering. Foxes should not be trapped for any reason during whelping and lactation (April through early June). The survivorship and reproductive success of shock-collared foxes should be determined. Collisions with vehicles should be mitigated by installation of speed bumps or dips on blind curves where vehicles are most likely to hit foxes. Fox control methods should be scaled back as the shrike population increases, and each method of predator control should be evaluated to determine which are the major contributors to shrike success.
4. Population and habitat monitoring for the 6 subspecies should be standardized. An integrated fox trapping database should be developed, with all agencies contributing current and historic data.

Management of Captive Fox Populations

1. Recent genetic information documents a possible lack of variation in genes for the major histocompatibility complex among island foxes on San Miguel and on Santa Rosa. In light of this and other evidence for lack of genetic variation, one can make the case that captive fox management may benefit from inter-island transfer of foxes, in terms of potential hybrid vigor. However, because there are grave concerns about the potential introduction of pathogens to naïve hosts, and the loss of taxonomic integrity from mixing subspecies, a thorough risk analysis should be completed for such a scenario. If risk assessment is favorable, an action plan should be developed.
2. The Santa Rosa captive fox population is nearing facility capacity, and release of animals into the wild is imminent. Choice of animals to be released is important. Recommend that the first release comprise two family groups released in the fall, with additional extra females released to facilitate extra-pair copulations. Prior to release the pedigree for the captive population should be refined, and animals should be chosen for release so as to minimize genetic impact to both the captive and wild populations.
3. Mainland zoos holding island foxes have an important role to play in conservation of the species. We recommend that such zoos contribute staff time, funding or other resources to the in situ conservation effort.

Island Fox Husbandry

1. Aggression during the breeding season has been recorded in both the zoo and island captive populations, with some considerable injury to individual foxes. The problem does not seem to be widespread. Recommend that pens not have common fences, and installing perimeter fences around all pens on islands that have free-ranging foxes.
2. Some fox pairs in captivity, particularly on San Miguel Island, have failed to reproduce in three years. The breeding failures may be due to failure to mate, male infertility, embryo/fetal loss, or infanticide. Recommend a variety of investigative techniques to discern cause:
 - Direct observation or video to document occurrence of courtship and mating behavior, infanticide
 - Fecal testosterone and semen collection to determine male infertility
 - Pregnancy diagnosis by ultrasound or relaxin blood test
3. The mainland zoo population should be used to conduct detailed studies of reproductive hormone patterns and stress.

Veterinary Care

1. Canine distemper virus, which caused the recent island fox decline on Santa Catalina Island, is the disease of most concern, but also one for which there is a safe vaccine. To protect captive fox populations from possible introduction of canine distemper virus, recommend vaccinating all captive foxes with monovalent recombinant canine distemper virus vaccine.
2. The wild population on San Nicolas shows serological evidence of recent exposure to canine distemper virus. If a serosurvey indicates that the wild populations on San Clemente and Santa Cruz are seronegative, or naïve (no history of exposure to canine distemper virus) then a cost/benefit analysis should be conducted to evaluate the need to vaccinate wild foxes.
3. Many foxes whose serum was recently tested had antibodies against canine parvovirus. Because parvovirus accumulates in the environment, most wild foxes are exposed to small doses, which may confer some protection. Because the parvovirus vaccine has limited effectiveness, requires frequent boosters, and not been tested for safety in island foxes, vaccination is not recommended at this time. Vaccination against rabies or canine adenovirus is also not recommended at this time.
4. The University of California has taken the lead on disease surveillance in island foxes. These efforts should be continued, and all agencies and landowners should cooperate. Methodologies include annual veterinary exams of captive foxes, serology, hematology, clinical chemistry, fecal analyses, ectoparasite evaluation, and complete postmortem exams on all foxes that die.
5. The USGS-Biological Resources Division Wildlife Health Center is conducting an evaluation of parasites in captive island foxes. To determine the current extent of parasite problems, sampling protocols have been developed and should be implemented beginning in fall 2002. Whereas the lack of clinical signs indicates that treatment is not warranted at this time, the concentration of animals in small areas could lead to problems. Captive pens should be managed to minimize build-up of parasites in the environment. Recommend removing feces daily, and disposing of feces at a more distant location. Treatment protocols will be developed, in the eventuality that clinical signs indicate treatment is necessary.
6. Knowledge of previous exposure to canine viruses is essential for determining disease threats, and for making decisions regarding vaccination. Serum collected from wild and captive island foxes in 2002 should be assayed for canine diseases. As time and funding permit, archived serum from previous years' sampling should be assayed.

7. Consistent protocols for medical procedures and sample collection would be advantageous for assessing overall population health and conducting investigations. Some veterinarians already have protocols in place that could serve as templates for the island fox program; these protocols should be circulated among the island fox veterinarians for review and then distributed to all sites and investigators working with island foxes.
8. Because some conservation and management actions can have impacts on island fox health, veterinarians should be consulted before such actions are implemented. Some management actions that are of concern are the use of animal poisons in the wild (such as the rodenticide Quintox), trapping protocols that may result in fox injury (leg-hold traps) or death (eg. from hyperthermia), and use of dogs for pig removal from the islands.
9. The potential for transmission of disease from domestic and feral animals remains a grave concern. Feral cats on Santa Catalina should continue to be surveyed for presence of diseases. Health requirements should be established for dogs coming onto the islands, such as dogs used in pig removal operations.

Appendix B Captive Breeding Working Group Notes, 2002

CAPTIVE BREEDING BEHAVIOR/HUSBANDRY Cheri Asa, Group Lead

Participants:

Cheri Asa, St. Louis Zoo
Scott Johnson, IWS on Santa Catalina captive breeding facility and field work
Kevin Bren, Orange County Zoo
Ian Williams, San Miguel Island ranger
Stacey Lehmann, San Miguel fox caretaker
Janna Edwards, Santa Barbara Zoo, large mammals
Sheri Schroeder, Santa Barbara Zoo, birds and foxes
Marsha Sovada, Northern Prairie Wildlife Research Center, USGS, swift foxes

Issues for Discussion:

2. Mate selection in captivity
7. What can we learn from the mainland zoo population that will aid management
13. Monitoring captive foxes during breeding season on San Miguel Island
18. Role of captive gray fox research colony
24. Design of pens relative to stress/lack of reproductive success
27. Intense behavioral study to look at M/F aggression during the breeding season.

Aggression Issues

Aggression seems to be a problem in particular circumstances and is not widespread.
May be more of a problem during the breeding season, but we don't have data on how early testosterone increases in males
Infanticide has been documented, but seems not to be typical nor widespread

Recommend pens not have common fences and that pens have perimeter fences on islands with free - ranging foxes

Monitoring Captive Foxes

Don't know whether breeding failures are due to failure to mate, male infertility, embryo/fetal loss, or infanticide

- Occurrence of courtship and mating behavior can be documented by direct observation or video
- Male infertility can be evaluated via fecal testosterone and semen collection
- Fetal loss can be documented by pregnancy diagnosis via ultrasound and perhaps by blood test for relaxin
- Infanticide can be monitored by video

Problems with observation and video:

- Electricity for video cameras/recorders

- Foxes don't typically use den-boxes to deliver
- Pen design makes video of whole enclosure impossible
- No good vantage point for observing all pens

Pen Design

- New pens might be designed with monitoring in mind, e.g., rectangular (foxes can still hide in den boxes).
- Based on information from other captive canid colonies, group doesn't feel that more space between pens is important.
- Den boxes should have hinged roofs for monitoring and access to foxes.
- Portable "Peeper" camera uses D-batteries and can be used to look inside den boxes

Using Mainland Zoo Population

- Collect fecal samples from females starting in mid-January to cover estrous period
- Collect monthly fecal samples from males to delineate annual testosterone pattern
- Collect fecal samples before and after events that might be stressful to establish cortisol patterns
- Collect semen samples to begin documenting semen quality for the species.
- Collect blood and do ultrasound exams during mid-gestation to validate relaxin assay for the species

Using Gray Fox Colony as a Model for Island Foxes

- Reproductive work (female cycles, semen banking, artificial insemination)
- Vaccine testing ??
- Testing medications

Mate Choice Design

Female choice more consistent with mating system that includes monogamy with paternal care
Problems with implementation:

- Male aggression if presented to females simultaneously, unless restrained behind fencing or in small cages.
- Excess females on Santa Rosa (4.9) so few males to choose from

Since San Miguel has excess males (6.2), combining populations would allow ample selection

Diagnosing Reasons for Reproductive Failure

Recommendations

- Semen evaluation using electroejaculation of males that have been paired with females but have not reproduced in 2 or more years
- Attempt to observe copulations or copulatory ties to determine whether there are compatibility or behavioral problems
- Continue monitoring female fecal hormones and add relaxin blood test if it is validated in this species

Captive Population Management

Phil Miller, Group Lead

Participants:

Melissa Gray, UCLA
Andrea Lehotsky, Channel Islands National Park
Phil Miller, Conservation Breeding Specialist Group
Julia Parker, Santa Barbara Zoo
Kathy Ralls, Smithsonian Institute
Keith Rutz, Channel Islands National Park
Rex Sohn, USGS-Biological Resources Division, National Wildlife Health Center
Alan Varsik, Santa Barbara Zoo

Issues to address (prioritized)

1. Captive strategy if eagles remain
2. inter - population breeding : parasites/disease/history
2. release strategies
4. What do we want captive facility on Cruz to accomplish
5. Goals for zoo populations
6. Role of mainland population in overall captive strategy
7. San Nicolas Captive populations? on island/mainland?

Issue #1 Captive strategy if eagles remain

need to think of the issue by island

Can we release if eagles remain?

- last year we said no, reconsider now?
- are the remaining sub adults on Cruz posing a threat?
 - posing a threat?
 - could be a F (pigs, fox behavior)
- are captive fox behaviors similar to wild behaviors?
- is captive space a problem?
- fox mortality data suggests that few eagles can cause marked predation
- do we take excess females and
 - release
 - build new pens?
 - breed between islands?

*Are animals that are not breeding in captivity better off remaining in captivity?

Should we breed captive born animals that may have lower survival in wild?

- What happens if eagles remain essentially permanently?
 - long - term yes
 - short - term ?

lack of captive space not a justifiable criteria for release . . . we can always building more pens if necessary

*Santa Rosa release in 2002?

pros

- pairs not breeding in captivity may breed after release
- additional data on severity of eagle problem - research value
- establish wild pop.
- reduce catastrophic disease risk
- maintenance of ecological processes
- possibly minimize time in captivity for individuals
- could be positive PR spin
- if fox mortality, increase awareness of golden eagle problem

cons

- some foxes would probably die
- loss of genetic variability from captive populations
 - loss is FCN (number of individuals in captivity)
- public relations risk - changing our tune from last year
- premature release before captive goal is reached, dependent on type of release
- losing options for working successful pairs in captivity

Working group recommendation:

A If eagles currently resident on Santa Cruz remain, then do not release on Santa Rosa in 2002

B If resident eagles are removed, then consider release base on appropriate management strategy

*Consequences of A for captive management strategy on Santa Rosa

- 2 empty pens; 4 with single female; 9 females, 4 male pups
- 8 single females - 1 three year old, 7 two years olds, one pair hasn't bred, is compatible, one pair hasn't bred, looks incompatible
- no apparent urgent need to build new pens to accommodate existing animals
- may want to consider movement of foxes between islands to improve captive population performance

Issue #2a Inter - island transfer strategies

[note mainland dogs visit Rosa and Miguel (on Rosa includes resident dogs and cats)]

pros

- potential hybrid vigor
- to better use existing breeder (balancing sex ratios)
- greater variety of management options
- able to test pathogen resistance, breeding propensity, etc..
- could reduce risk of losing San Miguel population

cons

- introduction of novel pathogens (parasites) to naïve population (could be lessened in intensively - managed captive populations)
- lose taxonomic integrity
- could have major policy - level complications
- would limit breeding options if unsuccessful

- outbreeding depression?

*consider one directional movement between islands

- little evidence for decrease fitness among crosses between subspecies, species

Working Group Recommendation:

**conduct a thorough risk assessment of movement of foxes between Miguel and Rosa*

include:

- demographic model of existing Miguel population
- risk of pathogen transmission
- risk to Rosa of removing animals

**consider one directional movement between islands*

Rosa females to Miguel

- parasite considerations
- augment Miguel population
- more space on Miguel

*If risk assessment is favorable, we recommend developing an action plan that includes movement captive foxes among selected island pops.

Issue #2b Release Strategies

(for Rosa)

*General issues

Who to release?

- pups
- litters?
- family groups?
- mated pairs?

When to release?

- seasonality
- factors that influence this
 - environmental cues

How to release?

- hard vs. soft release
- supplemental diet?

Where to release?

- appropriate sites
 - near where captured?

How to monitor after release?

What to do if release fails?

Day 2

Release Strategies continued:

*who should be chosen for release on Rosa in Fall of 2002?

Criteria:

- mean kinship of animals in captive pop
high MK= less genetic importance
- Demographically, better population growth is expected if mated pair is released
- Family groups may be better since pup (juvenile) survival could be greater (already demonstrated to be 100% on Catalina)
- Protocol:
 - refine pedigree with genetic analysis
 - choose pairs with lower genetic importance
 - depending on level of importance, decide if pups should be released with parents or retained in captivity
- A number of unpaired females could be suitable for release, depending on pedigree . . . consider releasing extra females with family groups
- * - recommend two family groups released in Fall with/without pups, plus extra females as feasible since extra - pair copulation exists
- *IF EAGLES REMOVED
 - will inoculate prior to release
 - will need to radio collar
 - must build perimeter fence around facility
 - no gut piles (eagle attractants) left behind
 - supplemental feeding as required

*How do we define failure in this release?

- mortality in excess of tolerable levels - approx. 20% adult mortality rate annually
- have to stick with it . . . can't panic after one year of questionable performance
- if everybody dies, must re - evaluate protocol and decide on next year's program.

Issue #4 What do we want captive facility on Cruz to accomplish?

*current capacity =10 breeding pairs

*recommended uses:

- genetic reservoir
- "pass-through" facility?
 - augment breeding success while minimizing adaptation to captivity
- consider expansion of facility if wild population decline continues
- research opportunity

*What to do with this year's production?

- consider release as pairs after bringing in required number of opposite sex

Issue #5 Role of mainland Zoo population

*AZA recommendation: PMP for research

*if inter - island breeding recommended on islands, consider the same for zoo population ...don't do it on mainland if not on islands

*4 current founders, 9 potential founders

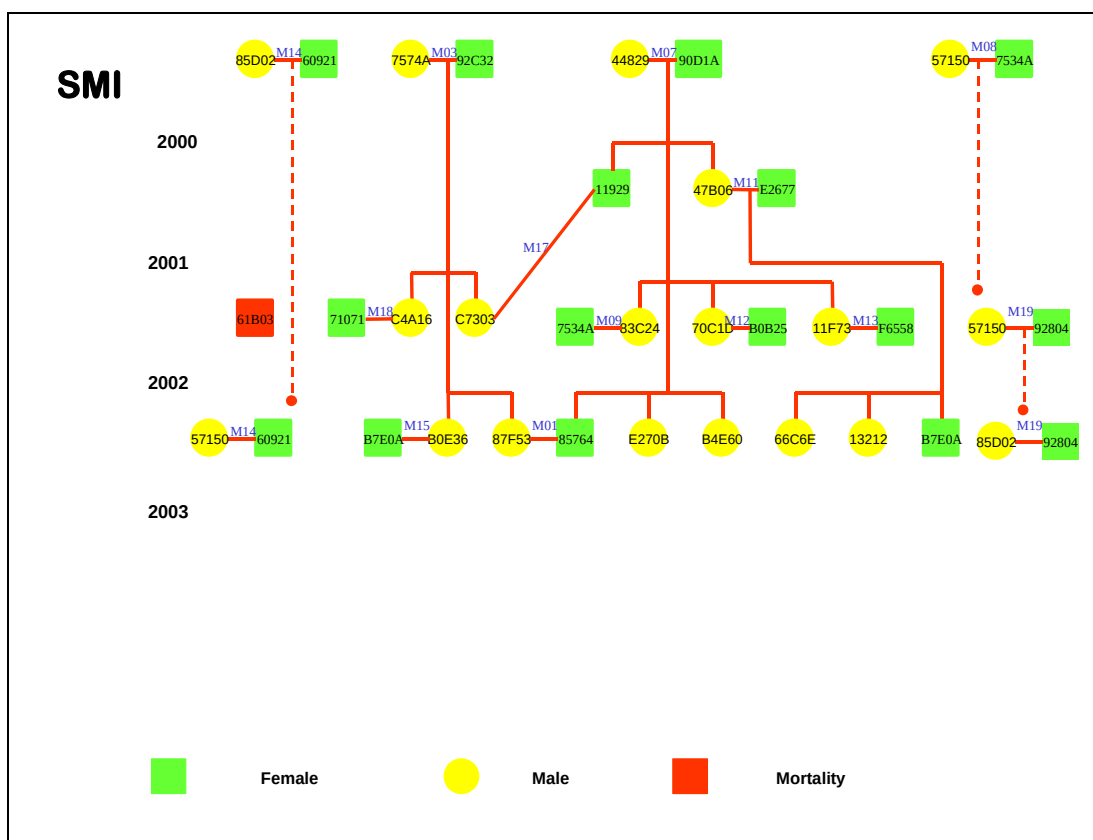
*Catalina conservancy could take in small number of injured animals from that island for educational purposes?

*We suggest that zoos holding foxes should be recommended to contribute resources - personnel, \$ to in-situ conservation effort ..also need to tell the story of fox conservation - make the story consistent across agencies, institutions.

Issue #6 San Nicolas Captive Populations

*Group recommends that it is not necessary at this time, on island or mainland.

Appendix C Captive Island Fox Breeding Charts



2003

Released to wild 12/05/02

Female

Male

Mortality

