

National Park Service
Channel Islands National Park

***ISLAND FOX CAPTIVE BREEDING PROGRAM
2001 ANNUAL REPORT***

Technical Report 02-01

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Captive island fox, Santa Rosa Island

Executive Summary

In 1999, the National Park Service established a captive breeding program for island foxes (*Urocyon littoralis*) at Channel Islands National Park, in order to restore wild populations of island foxes to viable levels. During 2001, the captive population of island foxes at Channel Islands National Park increased from 38 to 51 animals due to production of pups in spring 2001. The San Miguel captive population grew from 16 to 20 foxes, with 1 fox left in the wild. The Santa Rosa Island captive population grew from 22 to 32 foxes, and the last wild fox was brought into captivity in March 2001. There were 2 mortalities in the captive facilities in 2001. An adult female on Santa Rosa died of complications due to cancer in February, and an adult female died on San Miguel in December, most likely of old age.

In 2001, 10 pups were born to 5 litters on Santa Rosa Island, and 5 pups were born to 2 litters on San Miguel. Seven of 13 paired females produced litters in 2001 (54%), compared to 4 of 7 paired females in 2000 (57%). Average number of pups produced per litter was 2.2 over the two years of captive breeding. Only 2 of 5 pairings on San Miguel Island have been successful in that time period.

In October, pairings were made for the 2001-2002 breeding season. There are 10 pairs on San Miguel and 12 pairs on Santa Rosa. Genetic analysis conducted on the captive fox populations allowed determination of relatedness among foxes, and was used to select pairings. Two existing pairings, one on each island, were broken up because the genetic analysis determined a high degree of relatedness between male and female in each pair.

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. Fecal samples were collected for parasite screening. Captive foxes on San Miguel harbor three parasites with potential to impact fox health: *Angiocaulus*, *Spirocerca* and *Uncinaria*. No foxes were treated for parasites in 2001, 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 spirocercids. Some foxes on Santa Rosa have significant flea infestations, and were treated with Advantage and Frontline during veterinary exams in October.

An additional captive breeding site was built on each island, both to accommodate the increased number of foxes in the growing captive population, and to reduce the probability that a disease or other catastrophe would result in the demise of the entire captive population. In order to further reduce the possible spread of pathogens, more stringent hygiene procedures have been implemented.

In 2001 the NPS released a draft recovery plan for island foxes on the northern Channel Islands. Demographic modeling was used to develop appropriate recovery goals for the three northern subspecies, and also to set the size and scope of a captive breeding program that would achieve those recovery goals within a reasonable timeframe. Accordingly, it was estimated that 20 breeding pairs, and hence 20 breeding pens, is necessary for sufficient annual production to bolster wild populations over a 5-10 year period.

With 32 foxes currently in captivity on Santa Rosa Island, it is likely that annual production in spring 2002 will increase the captive population above 40 animals, and thus allow release of foxes back into the wild in fall 2002. Such a release would also be dependent upon sufficient mitigation of predation by golden eagles (*Aquila chrysaetos*) on the northern Channel Islands. As of January, 2002 19 golden eagles had been removed from Santa Cruz Island, with 4 remaining.

The Island Fox Conservation Working Group is a loose affiliation of agency, conservancy, zoo, non-profit and academic representatives which has met annually since 1999 to consider the conservation needs of the island fox. The primary issue discussed at the June 2001 meeting was the status of the Santa Cruz Island

fox subspecies, and whether captive breeding was warranted for that population. The findings of the group were that captive breeding was warranted if a territorial pair of eagles was still on the island by October 1, 2001, or if field surveys indicated the wild fox population to be critically low at that time. By the October deadline there were 4 eagles left, including a territorial pair. Moreover, recent surveys for island fox distribution and abundance indicate there to be between 50 and 60 adult island foxes on Santa Cruz, and demographic modeling predicts a high probability of extinction for such a population size. Captive breeding is therefore required to protect a segment of the island fox population from continued predation, and to augment the wild population (provided eagle predation is minimized as a mortality factor). In 2002 the NPS and The Nature Conservancy will construct and populate a captive breeding facility for island foxes on Santa Cruz Island. Initial facility size is 10 breeding pens.

In December, 2001, the U. S. Fish and Wildlife Service proposed to list as endangered the following four island fox subspecies: San Miguel island fox (*U. l. littoralis*), Santa Rosa island fox (*U. l. santarosae*), Santa Cruz Island fox (*U. l. santacruzae*), and Santa Catalina island fox (*U. l. catalinae*).

In 2002 the NPS will release 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. Up to 12 eaglets may be hatched back on Santa Cruz Island annually from 2002 to 2004.

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 a different subspecies on each of the six islands, a distinction upheld by morphological and genetic work (Wayne et al. 1991, Collins 1993). The subspecies on the three northern Channel Islands are in serious 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 three subspecies in the Park (San Miguel Island fox [*U. l. littoralis*]; Santa Rosa Island fox [*U. l. santarosae*], and Santa Cruz Island fox [*U. l. santacruzae*]) as well as the subspecies on Santa Catalina Island (*U. l. catalinae*). A final rule listing those subspecies as endangered could be published as soon as December 2002.

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 (Coonan et al. 2000) with the adult population falling from 450 in 1994 to 15 in 1999. The Santa Cruz population declined from approximately 2000 adults in 1994 to perhaps less than 135 in 2000 (Roemer 1999), and the current population is probably 50-60 adults (Dennis et al. 2001; 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 have since declined to 31 animals, all in captivity (Coonan and Rutz 2001).

Using population viability analysis, 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 past 5 years (Roemer 1999). 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 (T. Coonan, unpublished data). In 2001, 8 of 27 radiocollared island foxes died from golden eagle predation (Dennis et al. 2001; D. Garcelon, Institute for Wildlife Studies, unpubl. data). This 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 contributing factor driving increased 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 increased from 14 to 20 animals after two years of reproduction. There is only 1 fox left in the wild on San Miguel Island. A captive breeding program was initiated for Santa Rosa Island in 2000. The captive population on Santa Rosa increased from 14 to 32 foxes after two years of captive breeding, and there are none left in the wild on that island.

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 surveys on Santa Cruz Island, the island with the most recent sightings, in late summer 1999. During that time period a helicopter crew working on East Santa Cruz Island noted a large stick nest in a canyon. Biologists from SCPBRG rappelled into the nest and confirmed that it was an active golden eagle nest, the first confirmed nesting by golden eagles on the northern Channel Islands. Among the prey remains found in the nest were two adult island foxes, piglets, and ravens. To date 19 golden eagles have been removed from Santa Cruz Island. Captured birds were released in northeastern California, and satellite telemetry indicates none have attempted to return to the islands. Four golden eagles remained on the island as of January, 2002. However, other golden eagles may disperse from the mainland to the islands, and eagle monitoring and removal may be necessary until feral pigs are removed from the island, or bald eagles re-established.

The current status of eagles and foxes on Santa Cruz Island indicates that captive breeding is warranted for that island fox population. In 2001, 8 of 27 radiocollared island foxes died from golden eagle predation, and recent monitoring suggests there are only about 50-60 adult island foxes on the island. This population is too small to persist over time. Therefore in 2002 NPS and TNC will work to establish captive breeding for island foxes on Santa Cruz.

In March, 2001, the Park released to the public 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, stating the 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 three island fox subspecies in the northern Channel Islands were set with the assistance of 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 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.

In 1999 and 2000, the NPS convened a group of experts to help evaluate the status of island foxes on park lands, and to make findings regarding appropriate recovery actions. The group met again in 2001, and its focused broadened to include concerns about all six subspecies. The group has decided to meet annually to continue this work. 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 four and perhaps as many as five of the six 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, and management of wild populations. 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 draft island fox recovery plan (Coonan 2001) identifies captive breeding as a critical recovery element necessary to bring island fox populations back to viable levels on the northern Channel Islands. Current island fox populations on San Miguel, Santa Rosa, and Santa Cruz Islands number 21, 32, and 50-60 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 two 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 population sizes now require the program to be focused 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.

Demographic modeling (Roemer et al. 2001b, Coonan 2001) has been used to set an augmentation schedule that will annually produce sufficient foxes to return the wild populations to viable levels. Program scope, facility size and configuration have been set accordingly.

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 sub-group of the Island Fox Conservation Working Group. Appendix B contains names and addresses for members of the island fox captive breeding group.

Guidance for design of captive enclosures and development of husbandry protocols was provided by 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).

Although cost savings might be realized if there was only one facility to serve both islands, separate facilities are required for each island because of the possibility of disease or parasite transfer. For the same reason, use of mainland facilities is not appropriate. Island foxes housed on the mainland would constitute potential vectors for mainland disease or parasites if returned to the islands.

The following general guidance is derived from recommendations made by the captive breeding sub-group in July 2000 and in June 2001. Full discussion is contained in the 2001 meeting notes (see Appendix C), and the following summarizes the recommendations:

Program Goals and Objectives

- Facility size and program duration will be determined by the production needed to achieve population goals for wild populations. Those goals will be set after island fox demographic modeling is conducted to determine vital rates of viable populations.
- No foxes should be released until golden eagles are removed from the islands.
- Program duration will depend upon survivorship of released foxes.

Facility Design and Construction

- Facility size sufficient to insure production is likely to be 25 pens (50 foxes) on each island.
- In order to minimize the chance of disease, parasites or other catastrophe causing extirpation of captive populations, two separate facilities are recommended for each island.
- Hire adequate staff for caretaking 40-50 animals at two sites.
- Consider increasing the distance between pens, while providing hiding places that still allow animals to have visual contact when they choose.
- Annual pen construction should be completed by October to allow pairs sufficient time to bond prior to breeding.
- Establish a minimum of two isolation areas at each facility.
- Address the threat of wildfire at captive breeding facilities via fire management actions, and availability of Vari-Kennels for evacuation.

Veterinary Care

- Foxes cannot be returned to the islands, if removed for any reason, because of possible disease/parasite transmission.
- Systematic (regular) veterinary exams need to be scheduled.
- Standardized veterinary protocols need to be established.
- Each captive breeding population must have access to a veterinary/quarantine facility where animals may be treated.
- Conduct serosurveys to assess the risk of infectious disease.
- Develop protocols to minimize the risk of people or equipment transferring pathogens among islands.
- Develop protocols to minimize parasite loads in the captive populations and treat infested foxes.

Caretaking and Handling

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

Breeding Strategy

- Maintain bonded pairs as long as they reproduce successfully; allow at least two seasons to assess reproductive success.
- Avoid pairings of siblings or parent/offspring. Use genetic testing of captive foxes to estimate relatedness, and so avoid pairing of related animals.
- Use video monitoring to document breeding behavior or lack thereof, and to record birth dates, pup fate, and neonatal care.
- Pair captive-born foxes with wild-caught mates, as long as this doesn't break up existing pairs, to minimize loss of wild behavioral traits.
- Establish a studbook.
- Presently, the main objective should be to maximize reproductive output; after successful reproduction is established, then rely more on genetic considerations.
- Recommend developing a method for allowing female mate choice.

- 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.
- Translocation of additional males to pair with excess San Miguel females is an option that should be considered by genetic advisors and veterinarians.
- It is premature to resort to artificial insemination.

Breeding Success

- It is not uncommon to have low or even no reproduction the first year animals are brought into captivity.
- Successful breeding and production of pups by one pair indicates that conditions were adequate for sexual behavior, gestation, parturition and parenting.
- Failure of other pairs on San Miguel is probably attributable to insufficient time for courtship and pair-bonding before the breeding season or to young age and inexperience of several animals.

Release Strategy

- Release a minimum of two family groups at a time
- Recommend soft release into suitable habitat
- Monitor survivorship of released foxes

Education, Research and Conservation

- Encourage regional zoos and other wildlife educational facilities to obtain and exhibit island foxes, in order to impart the conservation message about the species.
- Develop a management plan for the current mainland zoo population, which includes seven males and six females, all from San Clemente Island.

Program Standard Operating Procedures

Standard operating procedures have been developed for care of captive island foxes at the park's facilities, (Appendix D) and are updated as required.

Diet

Upon advice from Mary Allen of the National Zoological Park, the daily island fox diet consists a high-quality dry dog food (Innova® Dog™, Natura Pet Products, Inc.:25-28% protein, 10-12% fat), 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. Other native prey such as crickets, grasshoppers, and beetles are also fed, or available inside the pens, to the foxes depending on the season. The 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). Initially all foxes were fed 90g kibble plus an additional food item. Over time all captive fox weights increased (Table 1), with some individual foxes weighing over 3 kg. Some adjustments were made in the amounts of kibble fed to account for calories from additional food items, and the heaviest foxes had a percentage of regular kibble replaced with a diet kibble. Following discussions with the project veterinarian and others, and in light of recent findings that necropsied wild foxes lacked significant internal body fat (L. Munson, UC Davis, unpubl. data), captive fox weights of 3 kg are not considered obese, and are unlikely to have negative health effects on the foxes. Currently a typical fox feeding consists of 60-90g of dry kibble and 1-2 additional food items with amounts dependent on the food type. An example would be when quail (a large food item) are fed, kibble amounts are lower than when kibble is supplemented with 1-2 tablespoons of fruit or vegetables. If individual foxes weigh > 3 kg then 15%-30% of the base kibble diet is supplemented with a diet high-grade kibble and fatty foods such as nuts are curtailed.

Lactating females and pups receive a canine growth formula kibble during pregnancy, whelping, and weaning. The canine growth formula kibble is gradually replaced with the standard kibble diet as pups reach adult size. Lactating females receive extra kibble, mice, quail, and eggs, with amounts dependent on number and size of pups, and often the amount of leftovers. Food items such as mice, quail, and eggs are also fed more often during the weaning stage to provide adults with food items large enough to provision pups with. Large intact natural prey items also provide stimulus for developing pups. Additional water appears necessary during the lactating and weaning stage and should be made available.

Animals are fed around dusk daily, and are provided with water ad libitum. Daily diet is recorded on a sheet (Appendix E).

Health/Medical

Foxes on San Miguel and Santa Rosa were given bi-annual veterinary examinations. Veterinary examinations were conducted by project veterinarian Mark Willett, D.V.M., of Davis, California, and by Sam Dover, D.V.M., of the Santa Barbara Zoo. On-island emergency care has been provided by Mark Willett, Sam Dover, Joe Herzog D.V.M., Ventura Emergency Animal Clinic, and Steve Timm, D.V.M., of the Institute for Wildlife Studies, Santa Catalina Island.

To date, routine veterinary examinations have been performed in a nose to tail fashion, and have included otoscopic and fundic examination. Blood samples are taken for complete blood counts and chemistry panels, and a portion is stored for potential disease screening and DNA analysis. Fecal samples are collected for parasite screening. Blood and fecal samples are sent to Linda Munson, D.V.M., at the Veterinary Medical Teaching Hospital, UC Davis, or IDEXX Veterinary Services, Inc.

Table 1. Captive fox weights over time. Shaded values are > 3.0 kg.

Fox	Sex	1999				2000				2001			
		W	SP	Su	F	W	SP	SU	F	W	Sp	Su	F
San Miguel													
11929	F								2.5	2.5	2.4		
11F73	M										1.35		2.6
44829	M	2.4		2.6					3.3		2.9		
47B06	M								2.8		2.6		
57150	M				2.65				3.2		2.85		3.1
60921	F			2.18					2.5		2.7		
61B03	F				2.3				2.6		2.6		
70C1D	M										1.1		2.35
71071	F			2.05					2.7		2.7		2.9
7534A	F			2.05	2.2				3.0		2.9		2.7
7574A	M	2.1	2.35	2.4					2.6	3.2	2.5		
83C24	M										1.3		2.5
85D02	M			2.38					3.0	3.25	3.15		
90D1A	F			1.85					2.3	2.35	2.3		
92804	F				2.6				3.0		2.8		2.3
92C32	F		2.3	2.5					3.25		2.5		
B0B25	F			2.2					2.4		2.6		2.75
C4A16	M										1.4		2.6
C7303	M										1.4		2.9
E2677	F								2.45		2.8		
F6558	F			1.9					2.3	2.25	2.2		2.7

Fox	Sex	1999				2000				2001			
		W	SP	Su	F	W	SP	SU	F	W	Sp	Su	F
Santa Rosa													
0654E	M							1.9		2.7		2.7	3.0
07061	F							2.05			2.4	2.1	
10030	F						2	2.35		3.1		2.75	
10445	F											2.4	
13C24	F							1.35		2.95		2.65	2.75
1612C	F					2.33		2.2		2.4		2.9	
2410E	F							1.75		3.0		3.1	2.8
34614	F											2.5	2.7
3512D	F							2.0		2.3		2.55	
37C61	F							1.8		3.0		3.1	
37E00	M							1.6		3.33		2.7	
53313	F						2.2	2.35		2.75			
60B1D	F											2.35	2.5
70518	M							1.5		3.2		2.7	
73D0D	M							2.05		2.6		2.5	
75125	M											2.7	2.9
84F28	M							1.85		2.7		3.1	
95B34	F							2.0		2.35		2.5	
96C28	F												2.6
A045A	M							1.7		2.75		2.8	
A180A	F									2.75		2.35	2.3
A7015	F						2.2	2.1					
B067E	M					2.55		2.4		2.65		2.9	
B4B2B	M											2.7	
C5864	F												2.9
D187A	F						2.45			2.3	2.15	2.35	2.5
D3D76	M					2.05		2.5		2.53		2.5	
E5100	F							1.85		2.8		2.35	2.45
E641E	F												2.7
F0223	M						1.9	2.4		2.65		2.65	
F3950	F											2.4	2.8
F3D2F	M											2.4	
F4A18	F					2.05		2.05		2.6		2.65	

Table 2. Island foxes in captive breeding facility on San Miguel Island (ages given are as of spring 2002).

Pen	PitTag	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
M03 ¹	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	9	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
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

¹Pens M03-M11 are at Willow Canyon site; pens M12-M19 are at Brooks Canyon site.

Captive Breeding Program Status

Overall Breeding Success

After two years of captive breeding, the number of island foxes in captivity increased from 28 to 52 individuals on San Miguel and Santa Rosa Islands. In 2001, the San Miguel captive population increased from 16 to 20 individuals, and the Santa Rosa captive population increased from 23 to 32 individuals. In spring 2001, 10 pups were born to 5 litters on Santa Rosa Island, and 5 pups were born to 2 litters on San Miguel. Seven of 13 paired females produced litters in 2001 (54%), compared to 4 of 7 paired females in 2000 (57%). The average number of pups produced per litter was 2.2 over the two years of captive breeding. Over the two years of captive breeding, 6 of 9 pairs on Santa Rosa Island produced litters, but only 2 of 5 pairs on San Miguel Island were successful in that time period. The reason for the low reproductive success on San Miguel is unknown. Two of 6 pairs with juvenile males produced litters. The one paired juvenile female did not produce a litter.

Expansion of Captive Breeding Facilities

Demographic modeling indicates that annual release of 12 foxes into the wild is required to reach targeted population goals within a decade. Accordingly, a captive population of 40 foxes (20 pairs) is the ideal size to meet or exceed this level of productivity. In actuality, production from a facility this size could be significantly more than 12 foxes per year. In two years of captive breeding, about 50-60% of paired females have bred, and average number of pups produced was 2.2. Thus, it is possible that 20 paired females would produce 22 pups per year.

Table 3. Reproductive success of captive San Miguel Island foxes, 2000-2001 breeding season.

Pen	PitTag	Sex	Age	Paired	Result	Pups Produced	Birth Date
M01	11929	F	1				
	71071	F	2				
M02	60921	F	3	10/2/99	No Litter	0	
	85D02	M	2				
M03	92C32	F	3	7/16/99	Litter	2M	04/14/2001
	7574A	M	3				
M04	61B03	F	8				
M07	90D1A	F	3	9/4/99	Litter	3M	04/02/2001
	44829	M	3				
M08	7534A	F	8	10/31/99	No Litter	0	
	57150	M	3				
M09	F6558	F	2				
	B0B25	F	2				
M10	92804	F	9				
M11	47B06	M	1			0	
	E2677	F	3	10/26/00	No Litter		

¹died in captivity December 12,

In FY2001 the park expanded its breeding facilities on both San Miguel and Santa Rosa to provide enough pen space to house 20 fox pairs on each island. To do this, an additional site of 11 pens was added to San Miguel Island, and 8 pens were added on Santa Rosa Island. The additional sites were set at sufficient distance from the original sites to minimize the spread of pathogens from one site to another, and to minimize the risk that a catastrophic event would decimate all captive foxes.

San Miguel Island Captive Breeding Facility

Breeding Success

During 2001, the San Miguel captive population (Tables 2-4) grew from 16 to 21 foxes, with 1 fox left in the wild, before an adult female died in captivity in December. Five pups, all males, were born to 2 litters in April, 2001. Three other pairings did not produce litters. One of those failed pairings (M11) contained a juvenile male, and so was less likely to breed. Another (M02) had failed to produce a litter the previous year as well, but showed signs of breeding behavior; they were moved to the new pen (M14) at Brooks Canyon. The third failed pairing (M08) did not produce the previous year, showed little sign of breeding behavior, and so was split for the 2001-2002 breeding season.

In October, pairings were made for the 2001-2002 breeding season. There are 10 pairs on San Miguel for the upcoming breeding season. With the death of adult female 61B03 in December 2001, there are no unmated foxes in the San Miguel facility.

Genetic analysis conducted on the captive fox populations (Gray and Roemer 2001) allowed determination of relatedness among foxes (Table 5) 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 on San Miguel had relatedness values suggesting they were unrelated (-.20 and -0.38, respectively), although the high overlap among San Miguel animals reduces the confidence of this determination. Consequently, observations of behavior were used to make decisions

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

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

*Founding population

about keeping pairs together. In this case, 85D02-60921 had shown signs of breeding behavior, whereas 57150-7534A had not.

Breeding Behavior of Individual Pairs

For the following discussion, *compatibility* is defined as actions or posture indicating relatedness or a pair-bond. Allo-grooming, facial and muzzle rubbing, extended play bouts, and physical contact during resting are strong indications of compatibility.

Breeding behavior are actions commonly displayed by canids in the period leading up to a copulatory tie. Increased scent-marking, double scent-marking and male sniffing of female urine and feces are early indicators. This period is followed by increasing male interest in the female's hindquarters, constant shadowing of the female by the male, vigorous play bouts, and attempted mounts and thrusting by the male.

90D1A (F) and 44829 (M) produced a litter of 3 pups in 2001, to bring their two-year total number of offspring to 5 pups (4 M, 1F). This pair exhibited increasing breeding behavior from mid-January through mid-February and whelping was believed to have occurred the first week in April.

92C32 (F) and 7574A (M) produced a litter of 2 pups after failing to reproduce last year. This pair showed increasing breeding behavior starting in late January, and was observed in a copulatory tie on the morning of February 16th, 2001. Whelping was believed to have occurred on April 14th, 2001.

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 produced. Because of their continuing reproductive behavior this pair was left together for the 2002 breeding season and moved to a more isolated pen at the new facility.

7534A (F) and 57150 (M) showed compatibility but little in the way of breeding behavior. Genetic analysis also showed an apparently higher degree of relatedness compared to other pairs. Therefore this pair was split up and each given a new mate for the 2002 breeding season.

Table 5. Relatedness values for island fox pairs on San Miguel Island (data from Gray and Roemer 2001).

Pen	Male	Female	Relatedness ¹	Repr.? ²	Action Taken
Previous Pairs					
M02	85D02	60921	-0.20	N	Moved to M14 at second site
M03	7574A	93C32	-0.35	Y	
M07	44829	90D1A	-0.07	Y	Pair split because of lack of breeding behavior
M08	57150	7534A	-0.38	N	
New Pairs					
M19	57150	92804	-0.71		

¹ pairs with $r < -0.12$ are unrelated

² Y = has produced a litter; N = has not produced a litter

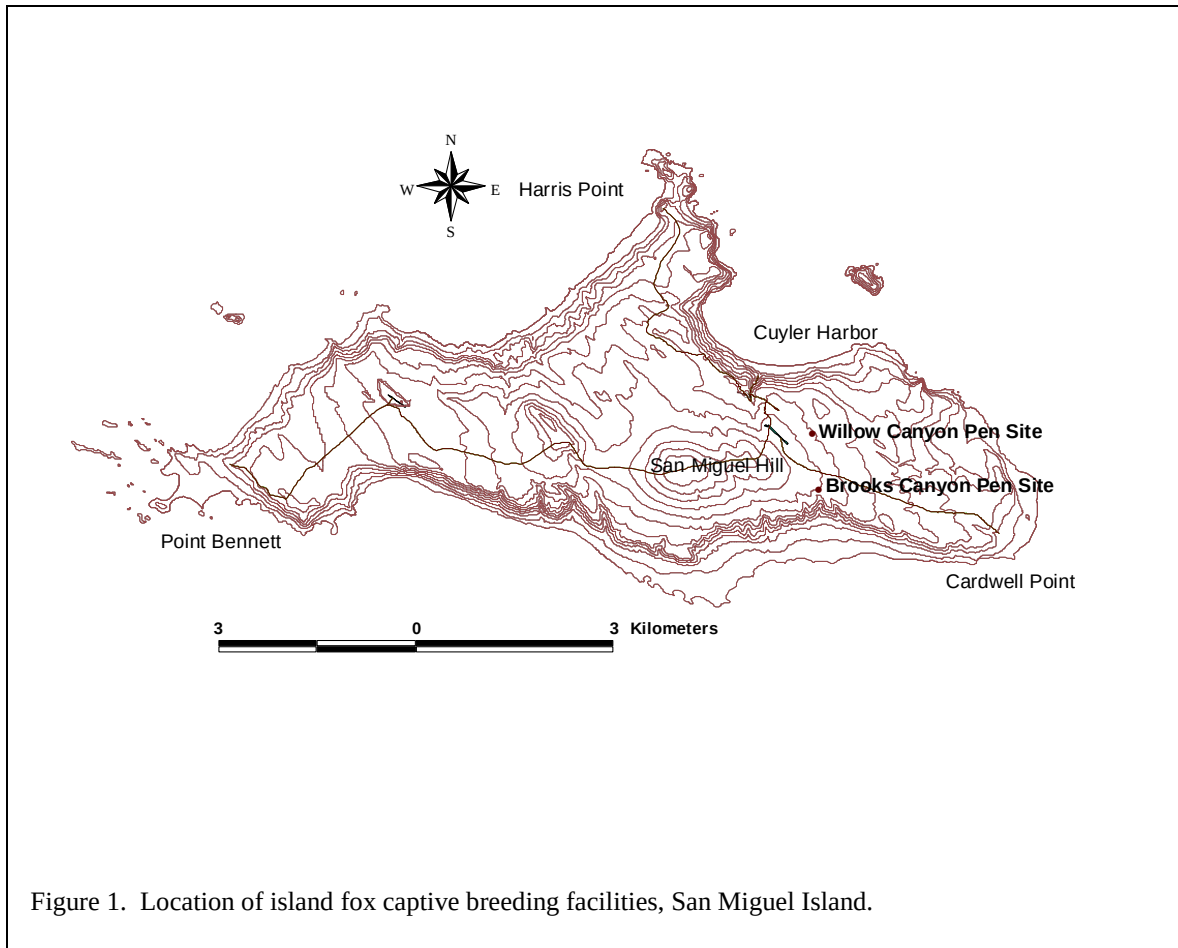


Figure 1. Location of island fox captive breeding facilities, San Miguel Island.

E2677 (F) and 47B06 (M) were paired for the first time in 2001. Although this pair exhibited compatibility and increasing breeding behavior beginning in early February they failed to produce a litter. This pair remains together for the 2002 breeding season.

Construction of Additional Pen Site

Eleven additional 500 square-foot pens were built on San Miguel Island in August 2001, at a second facility site known as Brooks Canyon (Fig. 1). The site is south of Cardwell Trail and runs east-west along the southern edge of a marine terrace over looking the shoreline. The pens are grouped in clusters of 3, 3 and 5 pens, with a minimum of 10 meters between pens and 100 meters between clusters. There is more native vegetation within pens compared to the Windmill Canyon facility, and greater exposure to wind and weather. Total number of pens on San Miguel is now 22 (19 500-square-foot breeding pens, one 300-square-foot breeding pen, and two 100 square-foot quarantine pens).

Pens are constructed with 1 3/8" 11-gauge chain-link fabric, fixed to 6' X 10' and 10' X 10' 1 5/8" tubular panel frames, saddle-clamped together with 1 5/8" X 1 5/8" saddle clamps. Pens are fully enclosed with 6' X 10' vertical walls, an 11-gauge hardware cloth ground skirt extending both into and outside the pens, and 10' X 10' roof panels. Multiple above and below ground shelter boxes are provided to each pen (Fig. 2), native vegetation is incorporated in and around the pens, and other pen enrichment options are being investigated. Shade cloth or other durable fabric is attached to pen walls as both a visual and wind barrier.

The design or footprint of each individual pen is based upon the topography and vegetation specific to that site. The basic idea is to use the 10' X 10' entry point area as the feeding and watering station, then minimize intrusions into the rest of the pen. In the remaining 400 square feet of pen space we tried to

Table 6. Results of fecal surveys for parasites in captive island foxes, 2001. Results are by pen, because scat samples were not identified to animal. A, S, or U indicates positive test for that parasite; * indicates a previous positive test for *Angiocalus* in 1999 (there were no positive tests for *Angiocalus* in 2000).

Pen	Male	Female	<i>Angiocalus</i>	<i>Spirocerca</i>	<i>Uncinaria</i>	Comments
San Miguel Island						
M01	11929	71071		S	U	
M02	60921	85D02	A	S	U	
M03	7574A	92C32	*	*	U	
M04	61B03			S	U	
M07	44829	90D1A	*	S	U	
M08	57150	7534A			U	
M09	B0B25	F6558	*	S	U	B0B25 positive for <i>Angiocalus</i> in 1999
M10	92804				U	
M11	47B06	E2677		S	U	
Santa Rosa Island						
R02	A7015	D3D76		S		
R04	1612C	B067E		S	U	
R05	F4A18	F0223		S		
R09	95B34	84F28		S		
R10	53313	A045A		S		
R11	3512D	73D0D		S	U	

incorporate native vegetation as cover and place possible denning areas as far from the entry point as possible. Our original U-shaped design has now been replaced with a modified L or Z shape.

Wild Fox Population

The remaining wild fox on San Miguel, female 85619, remained wild in 2001. 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 2002 for captive mating with a 2002-born male.

Health/Medical

Veterinary examinations of San Miguel foxes were conducted by Dr. Mark Willett, DVM, project veterinarian, in June 2001. 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 dramatic absence of ectoparasites in the San Miguel foxes, compared to Santa Rosa foxes, and there is very little problem with crusty eyes. One fox had a foxtail deep in his ear, but was not treated for it, because the ear was otherwise very health-looking.

One island fox died in captivity on San Miguel Island in 2001. On December 12th, 2001 the caretaker noticed a change in behavior in 61B03, a 9-year old female on San Miguel Island. The fox was removed from the pen and brought to the Ranger Station, where its condition deteriorated over the several days. The fox died on December 15, 2001 and was subsequently sent to Dr. Linda Munson at UC Davis for necropsy.

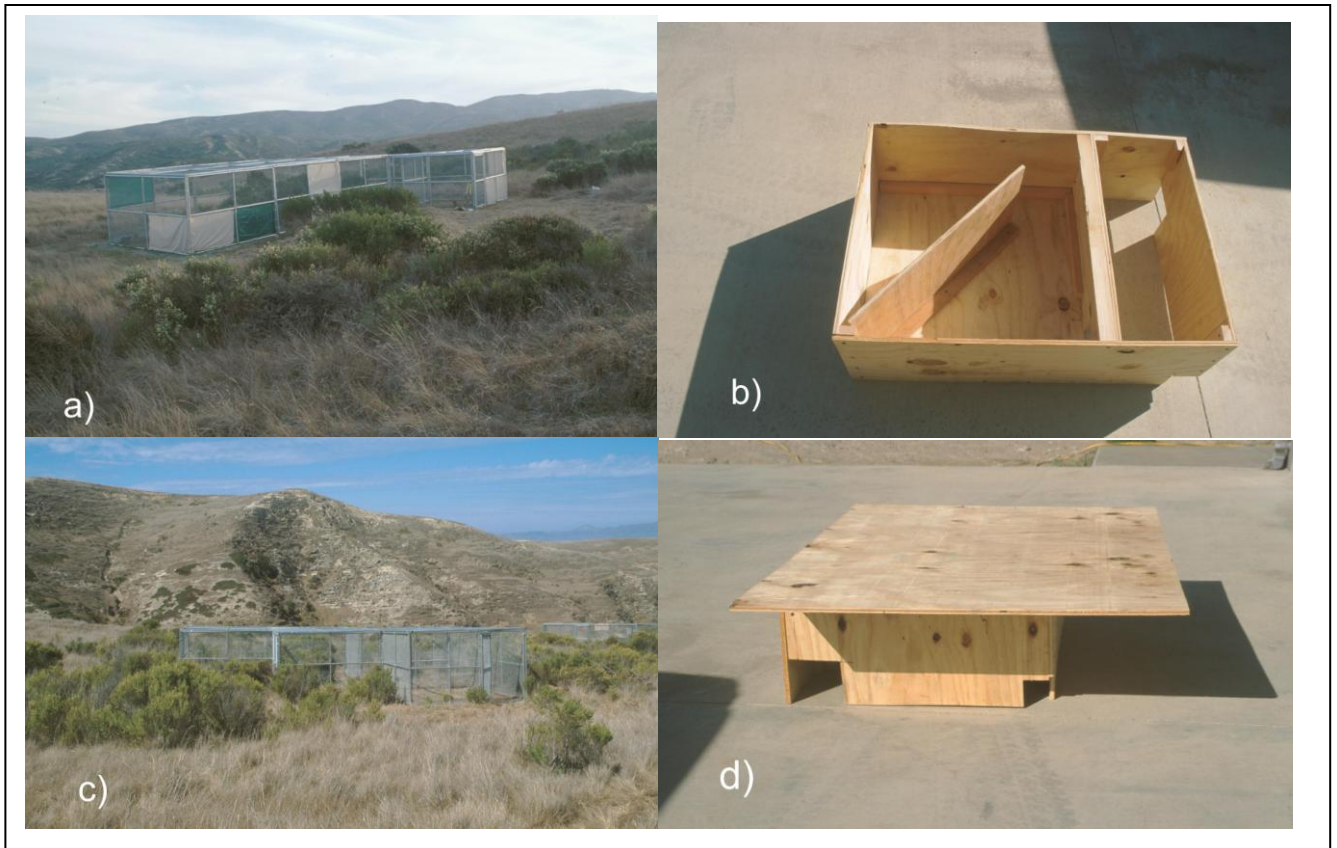


Figure 3. Breeding pens and shelterboxes: a) L-shaped pen; b) shelter-box interior; c) Z-shaped pen; d) shelter-box exterior.

Two pups examined in June had pale mucous membranes, and blood tests showed these foxes to have two of the lowest hematocrit values among all the foxes tested. Because they were acting normally, no action was taken.

Female 61B03, which died in captivity in December, was noted in June to have areas of alopecia (hair loss), possibly due to old age.

Foxes showed low levels of stress during capture and examination, with one exception. Female 60921 was observed limping after examination. Upon recapture, she was noted to have lost a nail, exposing the nail bed on a digit. She was treated with the antibiotic Baytril and recovered shortly thereafter.

Captive foxes on San Miguel Island have three parasites which have the potential to pose significant health problems: *Angiocaulus*, *Spirocerca*, and *Uncinaria*. Foxes in four pens on San Miguel have tested positive for *Angiocaulus* (Table 6). It does not appear to be spreading. In contrast, incidence of *Spirocerca* has increased from one pen in 1999 to six pens in 2001, and all foxes tested in both 1999 and 2001 had *Uncinaria*. Actual parasite loads are unknown.

Foxes on Santa Rosa have shown no sign of *Angiocaulus* and very little *Uncinaria*, but all appear to have spirocercids.

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.

Santa Rosa Island Captive Breeding Facility

Breeding Success

During 2001, the Santa Rosa captive population (Tables 7-9) grew from 22 to 32 foxes. Ten pups (3 males, 7 females) were born in captivity. An adult female fox died of cancer in March 2001, and the last wild island fox was brought into captivity in May. Five of 8 pairings produced a litter in 2001. Two of the three pairs which failed to produce a litter comprised one or two first year animals. The other pair failed to produce the year before and showed high relatedness, and so were split for the 2001-2002 breeding season.

In October, pairings were made for the 2001-2002 breeding season. There are 12 pairs for the upcoming breeding season, and 7 unmated females. Given past reproductive success, it is possible that the 12 pairs could produce as many as 16 pups in spring 2002. Such production would push the captive population above the facility's 40-fox capacity, and would allow initial releases of foxes back into the wild in fall 2002, provided golden eagle predation has been mitigated.

Breeding Behavior of Individual Pairs

Observations were limited at the Santa Rosa facility compared to San Miguel due to dense vegetative cover and lack of a video monitoring system.

1612C (F) and B067E (M) failed to produce a litter in 2001. Genetic analysis showed a high probability of relatedness in this pair and so they were split up for 2002.

F4A18 (F) and F0223 (M) produced 3 pups (2-F, 1-M) in 2001 bringing F4A18's two-year total to 7 pups. The pair showed strong compatibility when first introduced and F0223 is most likely the parent off the 2000 pups. F0223 was very defensive of the female in response to caretaker presence in the pen during whelping and weaning, often barking and approaching in an aggressive manner.

37C61 (F) and 37E00 (M) failed to produce a litter in 2001. Both were first year animals and the pair has showed compatibility. This pair was left together for 2002.

10030 (F) and 70518 (M) produced two pups in 2001 (1-F, 1-M). 70518 is a captive-born first year male paired with an older female. This pair showed strong compatibility often resting curled around each other.

Table 7. Island foxes in captive breeding facility on Santa Rosa Island (ages given are as of spring 2002).

Pen	PitTag	Sex	Age	Born	Sire	Dam	Date Captured	Capture Area
R01	60B1D	F	1	Captive	84F28	95B34		
	10445	F	1	Captive	70518	10030		
	F3950	F	1	Captive	0654E	D187A		
R02	D187A	F	4	Wild			4/5/00	Smith Highway
	0654E	M	2	Captive		A7015		
R03	2410E	F	2	Captive		1612C		
	B4B2B	M	1	Captive	F0223	F4A18		
R05	F0223	M	4	Wild			4/6/00	Smith Highway
	F4A18	F	3	Wild			3/29/00	Smith Highway
R06	37C61	F	2	Captive		F4A18		
	37E00	M	2	Wild			9/9/00	Skunk Point
R07	10030	F	4	Wild			4/5/00	Smith Highway
	70518	M	2	Captive		A7015		
R09	95B34	F	3	Wild			9/1/00	Torrey Pines
	84F28	M	2	Captive		F4A18		
R10	A045A	M	2	Captive		A7015		
	53313	F	3	Wild			4/3/00	Smith Highway
R11	3512D	F	4	Wild			11/5/00	Skunk Point
	73D0D	M	3	Wild			7/24/00	Torrey Pines
R12	07061	F		Wild			5/14/01	Windmill Canyon
R13	34614	F	1	Captive	F0223	F4A18		
	C5864	F	1	Captive	F0223	F4A18		
R14	E5100	F	2	Captive		F4A18		
	F3D2F	M	1	Captive	70518	10030		
R15	96C28	F	1	Captive	0654E	D187A		
	75125	M	1	Captive	73D0D	3512D		
R16	13C24	F	2	Captive		F4A18		
	B067E	M	4	Wild			3/26/00	Smith Highway
R19	D3D76	M	3	Wild			3/24/00	Smith Highway
	1612C	F	3	Wild			3/23/00	Smith Highway
R20	E641E	F	1	Captive	73D0D	3512D		
	A180A	F	2	Wild			10/24/00	Skunk Point

D187A (F) and 0654E (M) produced two female pups in 2001. 0654E is a captive-born first year male mated with an older female.

95B34 (F) and 84F28 (M) produced one female pup in 2001. 84F28 is a captive born first year male mated with an older female.

53315 (F) and A045A (M) failed to produce a litter in 2001. A045A is a captive-born first year male mated with an older female. This pair has not shown strong compatibility and when observed are most often resting separately. This pair was left together for 2002.

Table 8. Reproductive success of captive Santa Rosa Island foxes, 2000-2001 breeding season.

Pen	PitTag	Sex	Age	Paired	Result	Litter Size	Birth Date
R02	A7015*	F	3	10/19/00			
	D3D76	M	2				
R03	E5100	F	1				
	2410E	F	1				
R03	13C24	F	1				
	A180A	F	1				
R04	1612C	F	2	3/31/00 NL		0	
	B067E	M	3				
R05	F0223	M	3	10/19/00 Litter		3	4/3/01
	F4A18	F	2				
R06	37C61	F	1	10/19/00 NL		0	
	37E00	M	1				
R07	10030	F	3	10/19/00 Litter		2	
	70518	M	1				
R08	D187A	F	3	10/19/00 Litter		2	
	0654E	M	1				
R09	84F28	M	1	10/19/00 Litter		1	
	95B34	F	2				
R10	A045A	M	1	10/19/00 NL		0	
	53313	F	2				
R11	73D0D	M	2	11/5/00 Litter		2	4/14/01
	3512D	F	3				

*died in captivity March 18, 2001, of complications due to cancer

3512D (F) and 73D0D (M) produced a litter of two (1-F, 1-M) in 2001. This is a wild caught pair in the 2-3 age class.

Construction of Additional Pen Site

Eight additional pens were constructed on Santa Rosa Island in August 2001 at a second site named Caballo Del Muerto. The site is located just east of Park Service housing in a grassland/shrub vegetation community (Fig. 3). Distance between the new pens is 10-50 meters. Total number of pens on Santa Rosa is 22 (19-500 sq./ft, 1-700 sq./ft, and 2-100 sq./ft quarantine pens).

Table 9. Growth of captive island fox population, Santa Rosa Island.

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

¹Founding population

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

Health/Medical

Captive Santa Rosa Island foxes received veterinary examinations from project veterinarian Dr. Mark Willet, DVM, in January and September of 2001. 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.

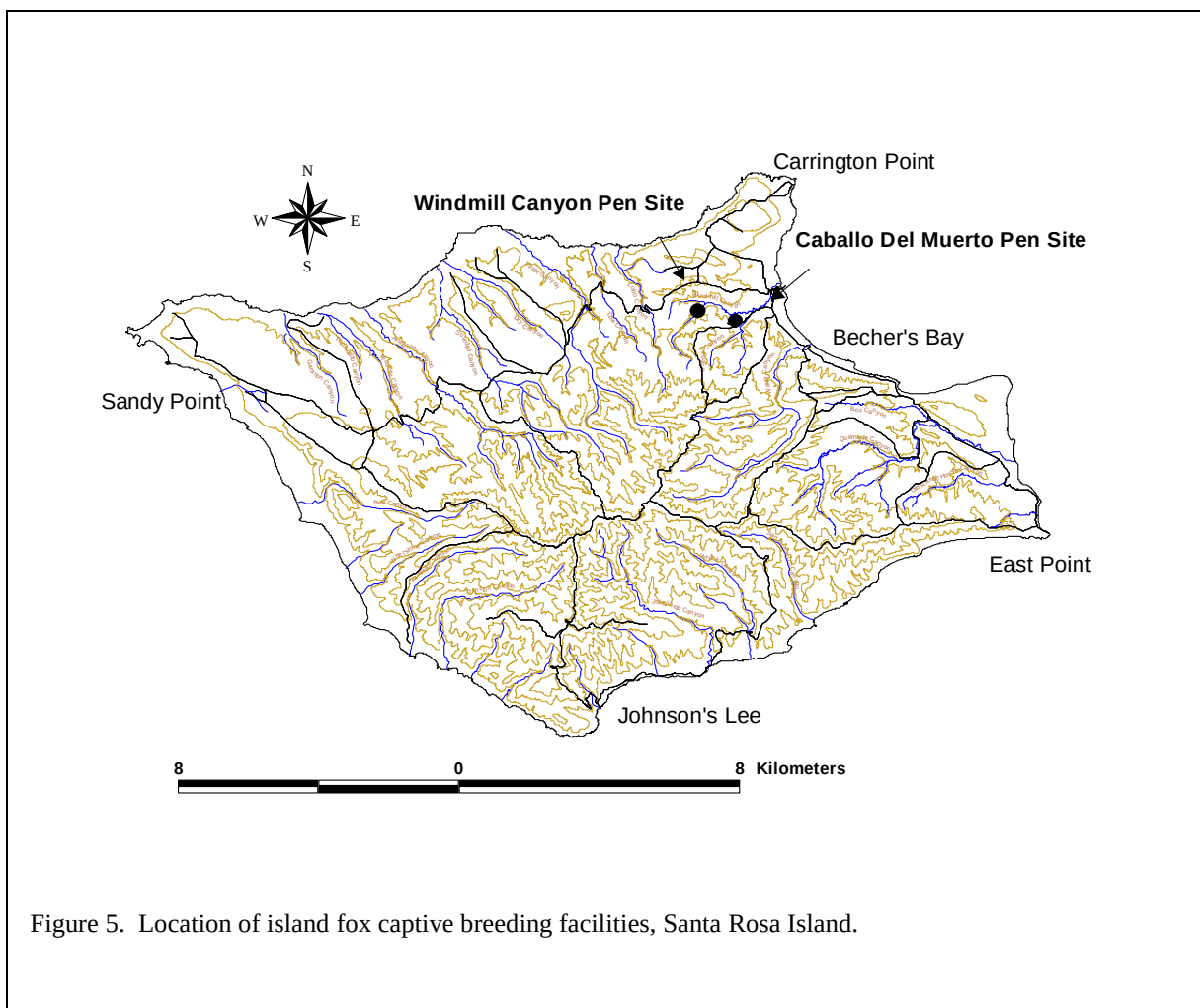
Foxes examined were in generally good or excellent condition, with a few exceptions. One island fox died in captivity on Santa Rosa Island in 2001. During a routine physical exam on January 17, 2001 a growth was found on the upper soft palate of A7015, a 3-year old female on Santa Rosa Island. A biopsy was performed the following day and results a few weeks later showed a malignant growth. On February 3, 2001 laser surgery was performed on A7015 to remove the growth in the hopes that she could make it through one more breeding season. Unfortunately, the cancer had already spread and A7015 died on March 18, 2001.

In January, female A180A had a small circular lesion 1-2 cm in diameter on the back of her neck. Analysis of aspirate from the wound indicated the presence of bacteria normally found in the mouth, suggesting it was a bite wound. In September, additional skin lesions were noted, and clinical tests showed simple normal inflammation. Similar wounds on D187A were treated with the antibiotic Baytril in late June; by October, the wounds were noted to be healed.

Several foxes weighed over 3.0 kg in January and were subsequently placed on a lower calorie diet. After discussion of fox weights at the annual island fox meetings, there was consensus among island fox caretakers that higher weights are not necessarily a cause for concern. Heavier foxes may fare better under stress or disease, although Dr. Willet notes that it is more difficult to obtain femoral blood samples from foxes weighing at or above 3.0 kg.

Stress levels of foxes during examination were low, except for female D187A, who has a history of negative reactions to handling. She prolapsed her rectum during an examination in 2000, and bit through her lower lip during capture for the January exam.

Foxes on Santa Rosa have more problems with ectoparasites (fleas and ticks) than do San Miguel foxes. Several foxes were treated for fleas with Advantage in May. During both vet examination periods, ticks were noted in some ears, but because the ears were otherwise healthy, no action was taken. Some foxes on Santa Rosa continue to periodically have discharge in one or both eyes. These conditions are generally not severe enough to warrant treatment, although in one case the discharge was cleaned out and the fox given a one-time dose of ophthalmic antibiotic.



Island Fox Captive Breeding Tasks

Establish Captive Breeding on Santa Cruz Island

Recent studies (Dennis et al. 2001) indicate that there may be only 50-60 adult island foxes left on Santa Cruz Island. Predation by golden eagles is still a significant mortality factor for island foxes on that island. In 2001, 8 of 27 radiocollared island foxes died from eagle predation, and four golden eagles remain on the island as of February, 2002. Captive breeding is now warranted for this subspecies, in order to protect a portion of the population from eagle predation, and to augment the wild population.

Accordingly, the NPS and The Nature Conservancy will establish and populate a captive breeding facility on Santa Cruz Island in 2002.

Project Lead: Tim Coonan, NPS, and Erik Aschehoug, TNC

Completion Date: March 15, 2002

Develop Release Strategy for Island Foxes on Santa Rosa Island

There are currently 32 foxes in captivity on Santa Rosa Island. Reproduction in spring of 2002 may push the captive population above the target facility size of 40 animals, allowing an initial release of foxes back into the wild (provided that golden eagle predation has been sufficiently mitigated). A strategy for release needs to be developed, one that includes method of release, composition of release groups, and monitoring. The NPS will develop a release strategy and send it out for review.

Project Lead: Keith Rutz

Completion Date: June 1, 2002

Budget

The island fox recovery efforts, including captive breeding, have been funded by a variety of National Park Service funding sources since 1999. Funding sources include the base budget of Channel Islands National Park, or parkbase; clusterbase funding from the NPS Pacific-Great Basin Support Office; the NPS servicewide Natural Resources Preservation Program (NRPP), the servicewide recreational fee demonstration program, U.S. Fish and Wildlife Service, and The Nature Conservancy.

1999-2001 Costs

Implementation of emergency fox recovery efforts at Channel Islands National Park began in late spring of fiscal year 1999 (October 1, 1998 to September 30, 1999). Recovery actions were funded by both the park and by the clusterbase. These funds were used to build pens on San Miguel, trap foxes and caretake for captive foxes, and begin golden eagle removal from Santa Cruz Island. Total monies expended were \$106,558, of which \$86,340 went to establish the captive breeding program on San Miguel Island.

Costs increased in fiscal year 2000 because captive breeding was added on Santa Rosa Island, and eagle removal efforts continued all year long. Total amount expended on island fox recovery at Channel Islands National Park in FY2000 was \$346,461, of which \$213,000 went to captive breeding.

Costs for fiscal year 2001 are presented in Table 10, along with funding sources. Those include the park's base account, a second year of NRPP funding, the remainder of the fee demonstration monies, and a U. S. Navy funding source. San Miguel Island is owned by the U. S. Navy and managed by the NPS as part of Channel Islands National Park. The U. S. Navy contributed \$100,000 toward island fox recovery efforts on San Miguel Island. Costs of captive breeding increased in FY2001 due to the costs of expanding the captive facilities on San Miguel and Santa Rosa Islands, as well as the costs of genotyping captive island foxes to determine relatedness. Total captive breeding expenditures in FY2001 were \$325,650.

Eagle removal in FY2001 was funded by the U.S. Fish and Wildlife Service and The Nature Conservancy. Island fox monitoring on Santa Cruz Island was funded by The Nature Conservancy as well.

Three years of NRPP funding for island fox recovery began in FY2000. The park received \$167,000 in FY2000 and in FY2001 and \$83,000 in FY2002 from this servicewide funding source.

Future Costs

The costs of the additional tasks outlined in this document are included in the FY2002 cost estimates (Table 11). The NPS and the TNC will share costs of establishing captive breeding on Santa Cruz Island.

Table 10. Island fox recovery costs at Channel Islands National Park, FY2001, including costs of captive breeding.

Fiscal Year 2001	NPS NRPP	NPS 20% Fee	Park Base	U.S. Navy	PLC SCA	TNC	USFWS	Total
Program Coord.			79,542					79,542
Captive Breeding								
Personnel	127,514			0	20,000			147,514
Island perdiem	7,686	5,337		6,220				19,243
Pen materials	1,280			27,718				28,998
Flights	18,884	18,360		9,862				47,106
Boat fuel				5,000				5,000
Helo ops				5,330				5,330
Fox food	1,192	2,992		498				4,682
Genetic study				28,391				28,391
Supplies/equip.	10,024	12,002		9,026				31,052
Vet care				3,371				3,371
Vet testing	420	2,368						2,788
Vet supplies		315		1,860				2,175
Total Capt. Breed.	167,000	41,374	79,542	97,276	20,000			325,650
Eagle Removal						25,000	30,000	55,000
SCI fox monitoring						50,000		50,000
Island Fox Meeting				2,724				2,724
TOTAL	167,000	41,374	79,542	100,000	20,000	75,000	30,000	512,916

Table 11. Estimated costs for island fox recovery efforts, including captive breeding, FY2002.

Fiscal Year 2002	NPF Settlement	NPS NRPP	NPS Parkbase	TNC	USFWS	Total
Program Coord.			82,724			82,724
Captive Breeding						
Personnel	159,242			48,000		207,242
Island perdiem	17,881					17,881
SCI Pen construction	15,000			20,000		35,000
Flights	32,560					32,560
Fox food	18,113					18,113
Supplies/equipment	7,200					7,200
Vet care	6,600					6,600
Vet testing	8,800					8,800
Vet supplies	1,000					1,000
Total Captive Breeding	266,396	0		68,000		334,396
Eagle Removal	34,000	75,000		16,000	38,000	163,000
SCI fox monitoring				100,000		100,000
Island Fox Meeting					4,000	4,000
TOTAL	300,396	75,000	82,724	184,000	42,000	601,396

Literature Cited

- American Society of Mammalogists. 1987. Acceptable field methods in Mammalogy: preliminary guidelines approved by the American Society of Mammalogists. ad hoc Committee on Acceptable Field Methods in Mammalogy. *Journal of Mammalogy* 68:1-18.
- Coonan, T. J. 2001. Draft recovery plan for island foxes (*Urocyon littoralis*) on the northern Channel Islands. National Park Service, Ventura, California. 72 pp.
- Coonan, T., and K. Rutz. 2001. Island fox captive breeding program, 1999-2000 annual report. Technical Report 01-01. National Park Service. 38 pp.
- Coonan, T. J., C. A. Schwemm, G. W. Roemer, and G. Austin. 2000. Population decline of island foxes (*Urocyon littoralis littoralis*) on San Miguel Island. Pages 289-297 in Browne, D. K., K. L. Mitchell, and H. W. Chaney, (eds.), *Proceedings of the 5th California Islands Symposium*. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region.
- Dennis, M., K. Randall, G. Schmidt, and D. Garcelon. 2001. Island fox (*Urocyon littoralis santacruzae*) distribution, abundance and survival on Santa Cruz Island, California. Progress report: May through October 2001. Institute for Wildlife Studies, Arcata, California. 32 pp.

- Georgi, J. V., and M. E. Georgi. 1991. Canine clinical parasitology. Lea and Febiger, Philadelphia. 227 pp.
- Gray, M. M., and G. W. Roemer. 2001. Genetic assessment of relatedness among individuals in the island fox (*Urocyon littoralis*) captive breeding program. Unpublished report on file at park headquarters, Channel Islands National Park, Ventura, California. 23 pp.
- Lyons, E. T., R. L. DeLong, S. R. Melin, and S. C. Tolliver. 1997. Uncinariasis in northern fur seal and California sea lion pups from California. *Journal of Wildlife Diseases* 33(4):848-852.
- Roemer, G. W. 1999. The ecology and conservation of the island fox. Ph.D. dissertation, University of California, Los Angeles.
- Roemer, G. W., T. J. Coonan, D. Garcelon, D. K. Bascompte, and L. Laughrin. 2001a. Feral pigs facilitate hyperpredation by golden eagles and indirectly cause the decline of the island fox. *Animal Conservation* 4: 307-318.
- Roemer, G. W., D. K. Garcelon, T. J. Coonan, and C. A. Schwemm. 1994. The use of capture-recapture methods for estimating, monitoring, and conserving island fox populations. Pages 387-400 in Halvorson, W.L., and G.J. Maender, (eds.), *The Fourth California Channel Islands Symposium: Update on the Status of Resources*. Santa Barbara Museum of Natural History, Santa Barbara, California.
- Roemer, G. W., P. S. Miller, J. Laake, C. Wilcox and T. J. Coonan. 2001b. Island fox demographic workshop report. Unpublished manuscript on file at park headquarters, Channel Islands National Park. 43 pp.

Appendices

Appendix A Findings of the Island Fox Conservation Working Group

**FINDINGS OF THE
ISLAND FOX CONSERVATION WORKING GROUP
JUNE 20-21, 2001
VENTURA, CALIFORNIA**

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SUMMARY:

From June 19-21, 2002, the Island Fox Conservation Working Group met in Ventura, California to exchange information about island fox status and recovery actions, to evaluate recovery efforts, and to identify management concerns and research needs. 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*).

According to the most recent information, four and perhaps as many as five of the six island fox subspecies are in decline or have declined catastrophically. Virtually all island foxes on San Miguel Island (22 foxes) and Santa Rosa Island (32 foxes) are currently in captivity. On Santa Cruz Island, the current population is unknown but could be as low as 40 foxes. The recent deaths of four radiocollared Santa Cruz Island foxes from golden eagle predation, and the presence of seven golden eagles on the island, indicate that golden eagle predation could drive the Santa Cruz population to extinction if not abated soon. San Nicolas Island has the only stable and dense population of island foxes at this point in time. Santa Catalina Island, which was recently decimated by canine distemper, has a population of about 200 foxes, most on the west end of the island. On San Clemente Island foxes may be in decline as well.

Captive breeding has been initiated on three islands, and a handful of island foxes are in mainland zoos and wildlife educational facilities. Before 2000, foxes had never been bred in captivity, and very little is known of island fox breeding behavior or reproductive biology. Several pathogenic parasites occur in captive and wild island foxes, but not on all islands. The San Miguel population in particular has high infection rates. Wild and captive foxes on Santa Catalina Island have been vaccinated against canine distemper virus with an experimental vaccine.

Channel Islands National Park has developed a draft recovery plan for island foxes. The plan proposes the extension of the current emergency recovery actions of golden eagle removal and captive breeding of island foxes to recover fox populations on the northern Channel Islands to viable levels. Recovery actions on Santa Catalina Island include vaccination of foxes, translocation of juveniles from the west end to the eastern portion of the island, and initiation of a captive breeding program. The Catalina Island Conservancy also plans to support an island pet vaccination program and is expanding its public education efforts on island fox conservation.

The most urgent threat to a wild island fox population is the continued predation by golden eagles on the Santa Cruz Island fox subspecies, which may be at a critically low population level. The remaining golden eagles need to be removed by October, 2001. If they are not removed by that time, or if the island fox population is found to be at a population level which is likely to decline to extinction, then captive breeding is warranted for the Santa Cruz Island fox population. An October decision deadline is necessary in order to provide enough lead time to establish a facility and bring foxes into captivity before breeding season (March-April, 2002).

Veterinary protocols must be established and standardized for all captive foxes, and all captive populations must have access to adequate veterinary facilities. Plans must be developed for treatment of captive foxes for pathogenic parasites. In order to determine cause of breeding failure, there needs to be increased monitoring of captive foxes, and resolution of genetic questions.

The mainland zoo population of island foxes from San Clemente Island is of great importance to furthering conservation efforts for the species as a whole.

The working group compiled a list of current stressors and potential threats to island foxes. Among the most important and pervasive are predation by golden eagles, the threat of canine distemper virus or other disease, the effects of pathogenic parasites, and the genetic and demographic consequences of small population size.

MEETING PARTICIPANTS:

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MEETING PURPOSE:

The purpose of the meeting was 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 five of the six 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, and management of wild populations.

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 radiotelemetry research by Dr. Gary Roemer, then of UCLA, and by biologists at Channel Islands National Park identified predation by golden eagles as the primary cause of the decline. In 1999, the National Park Service convened a group of experts to evaluate the species' status within Channel Islands National Park, and to identify any management actions required to prevent extinction and recover park populations to viable levels. The group 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 those emergency recovery actions in summer, 1999.

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. 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 should begin in 2003. Additionally, a consortium of agencies will test the feasibility of reintroducing bald eagles to the northern Channel Islands via an experimental release of eagles in summer, 2002, 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 by the Institute for Wildlife Studies and Dr. Linda Munson of UC Davis 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 three island fox captive breeding facilities on the Channel Islands, and island foxes are held in captivity at four mainland zoological institutions. Island foxes were never bred in captivity prior to establishment of these programs, and there are no established husbandry standards for the species. Many of the current captive breeding issues center around the development of appropriate husbandry methods and general guidance for captive breeding. The Santa Barbara Zoo is taking the lead on development of a husbandry manual for island foxes, following the guidelines of the American Zoo and Aquarium Association.

The threat of canine diseases required that island fox captive breeding be done *in situ* on the islands, rather than at mainland facilities. Parasite surveys by Dr. Linda Munson reveal that certain pathogenic parasites are specific to island foxes on different islands, necessitating an island-based approach to captive breeding, and confounding the treatment of captive foxes for parasites. Dr. Munson's necropsies of foxes from all islands indicate that many are under nutritional stress, and some have diminished thyroid function. Veterinary examination and care need to be adequate at each captive facility, and standardized.

The current most important issue in management of wild populations is the status of the Santa Cruz Island fox population, in light of the continued presence of golden eagles, and recent predation by eagles on radiocollared island foxes. The San Clemente Island fox population, although higher than any of the northern island populations, may be in decline for reasons that are unclear at this point. Island foxes on San Clemente are currently managed intensively as part of the predator management program for the Endangered loggerhead shrike.

In March, 2001, the NPS released a draft recovery plan for island foxes on the northern Channel Islands. The actions prescribed in the plan are an extension of the emergency actions implemented since 1999: removal of golden eagles, and captive breeding of island foxes. Recovery criteria were set for the San Miguel and Santa Rosa fox subspecies, and were based on the results of demographic modeling conducted by Dr. Gary Roemer of New Mexico State University and Dr. Phil Miller of the Conservation Breeding Specialist Group. To reach targeted island fox population sizes, about twice the current captive breeding capacity is required on each island. Accordingly, the NPS will build more pens at additional sites on both San Miguel and Santa Rosa this year. It may take 10 years to recover island fox populations, especially on San Miguel Island, where there is a small number of founders and low reproductive success of captive foxes. The estimated cost of recovery on the northern Channel Islands is over \$5 million.

STATUS OF EACH SUBSPECIES:

San Miguel Island

Only one fox remains in the wild on San Miguel, and there are 21 foxes in captivity. Those captive foxes include the 14 brought into captivity in 1999, and seven progeny. Only two pairings have produced litters. Dr. Linda Munson reports that the captive foxes are all infected with the hookworm *Uncinaria*, and many

are also infected with the lungworm *Angiocaulus gubernaculatus* (not seen in other island fox populations, or in other fox species), and a spirocerid. These parasites are considered to be pathogenic, but the foxes have not been treated with anthelmintics because of the possibility of a fatal reaction to treatment.

Dr. Cheri Asa of the St. Louis Zoo has conducted assays for reproductive hormones on island fox fecal samples from the San Miguel captive facility. The results of two years' assays suggest that island foxes are induced, rather than spontaneous, ovulators; the presence of a male is required for females to ovulate. This is significant because all canids studied to date have been shown to be spontaneous ovulators.

Santa Rosa Island

The last known wild fox on Santa Rosa Island was brought into captivity in March, 2001. There are now 32 in captivity, including 10 pups born in spring, 2001, and eight pups born in spring, 2000. The captive foxes are not infected with the pathogenic parasites found in the San Miguel foxes. At current growth rates, the captive population could exceed 40 animals by next breeding season, and captive foxes could be released back into the wild in fall 2002, provided eagle predation has been mitigated.

Santa Cruz Island

From 1999 to spring 2001 the Santa Cruz Predatory Bird Research Group removed 15 golden eagles from Santa Cruz Island. Captured birds were released in northeastern California, and satellite telemetry shows that none have attempted to return to the islands. According to Brian Latta of the Research Group, as of the meeting date there were seven eagles on the island, six of which comprised three pairs which attempted breeding in spring 2001. One of those pairs produced a chick, which was removed from its nest and fostered into a mainland nest. Attempts to trap the seven remaining eagles have been unsuccessful.

Dr. Gary Roemer of New Mexico State University estimated the Santa Cruz Island fox population to be about 135 adults in 1999. Because the population status and trend is unknown, The Nature Conservancy and the Institute for Wildlife Studies began an island fox study on Santa Cruz Island in December, 2000, to better estimate the distribution and abundance of island foxes, and to estimate survivorship of island foxes in the face of partial eagle removal. Dave Garcelon of the Institute reports that 33 foxes have been captured and marked since December, and that 16 foxes were radiocollared. Of those 16, four were apparently killed by golden eagles from March to June.

Golden eagle predation remains a significant mortality factor for Santa Cruz Island foxes. The island fox population level is unknown, but probably ranges between the minimum number known (less than 40) and 100 adult foxes.

San Nicolas Island

At this juncture, San Nicolas Island is the only island with a dense and stable island fox population. Grace Smith of the U. S. Navy reports that mark-recapture sampling in summer 2000 yielded an islandwide population estimate of about 735 foxes. Two of the sampling grids had estimated densities of over 16 foxes per square kilometer, which is the highest ever recorded for island foxes.

Santa Catalina Island

Dr. Steve Timm of the Institute for Wildlife Studies reports that in 1999-2000, island foxes on the eastern 80% of Santa Catalina Island declined by 95%, due to canine distemper virus. A total of 165 foxes have been trapped on the small west end of the island, which is isolated from the eastern portion by an isthmus which apparently acted as a barrier to spread of distemper. Following vaccine trials on captive island foxes with an experimental canary pox vaccine, 80% of wild animals trapped have been part of a vaccination program for canine distemper. Nine of 10 juvenile foxes translocated from the west end to the eastern portion have survived. In comparison, eight of 10 control (non-translocated) animals on the west end have survived.

Construction began on a captive breeding facility in October, 2000, and by mid-March 16 adults were in captivity. Of 18 pups born in the facility, six have survived, and will be released onto the eastern portion of the island this fall. The released pups will be monitored, and may be given supplemental food to ease their transition to the wild.

San Clemente Island

Dave Garcelon of the Institute for Wildlife Studies has conducted island fox population monitoring on San Clemente Island since 1988. The best estimate for the island fox population for 1993-1997 is about 640 foxes, but the number of animals trapped has declined in 1999 and 2000. Dr. Gary Roemer's demographic modeling had also indicated a long-term decline in the population from 1988 to 1997.

Island foxes on San Clemente Island have been managed intensively in areas where Endangered San Clemente loggerhead shrikes are breeding. In 1999, 15 island foxes were relocated to mainland zoos, and 13 were euthanized. In 2000 and 2001, foxes in shrike breeding territories were shock-collared to prevent their access to shrike nests, with some individuals being captured and held in captivity for a period of time after shrike nestlings fledged. The number of foxes held in captivity for this purpose was 77 in 1999, and 49 in 2000.

FINDINGS:

Management of Wild Island Fox Populations

Although island fox populations are threatened by a variety of factors (see Threats section below), the most critical current threat is the possibility that continued predation by golden eagles will drive the Santa Cruz Island fox subspecies to extinction. Given that the objective of the Santa Cruz Island stewards (the National Park Service and The Nature Conservancy) is to restore and maintain a viable wild population of Santa Cruz Island foxes, we make the following findings:

A resident golden eagle population is the present overriding factor in the current decline of foxes on Santa Cruz Island. The ongoing removal of golden eagles is a prerequisite for the successful recovery of the Santa Cruz Island fox population. Removal of eagles will become progressively more expensive as the number of eagles on the island diminishes.

Although removal of all territorial golden eagles is not a prerequisite for the establishment of bald eagles, a large proportion of the island must be free of golden eagles for the successful reestablishment of bald eagles, and the continued existence of island foxes.

Feral pigs provided the primary food source for the golden eagles to establish on the islands. The planned removal of feral pigs will likely prevent reestablishment of golden eagles.

Although park visitors are not allowed to bring domestic dogs to park islands, dogs may be used by the park in the future to eradicate feral pigs from Santa Cruz Island. Based on the catastrophic decline of foxes on Santa Catalina Island due to canine distemper virus, the presence of unvaccinated domestic dogs would constitute a significant threat to Santa Cruz Island foxes. Because of the close relationship of foxes and domestic dogs, dogs may carry a suite of diseases and parasites that pose varying levels of risk to island foxes. Any dogs used in pig eradication should be thoroughly vaccinated.

Based on the best present estimates of Santa Cruz Island fox population trends and mortality rates over the last two years, the continued decline will lead to extirpation in the near future.

If eagle removal is not successful, then extinction of the Santa Cruz Island fox subspecies can only be prevented by a fox sanctuary/captive breeding program. Thus, the existence of one pair of golden eagles on the island as of October 1, 2001 will warrant bringing foxes into captivity as the necessary conservative step in preserving the Santa Cruz Island fox population.

Captive breeding may still be warranted even if all golden eagles are removed, because the probability of extinction is high for a small population of foxes. Thus, if by October 1, 2001, the Santa Cruz Island fox population is deemed too small to avoid extinction, then a captive breeding program is warranted to recover the population to viable levels. The October deadline is appropriate because it gives sufficient lead time for materials to be ordered, pens to be built, and foxes brought into captivity prior to the critical period for fox whelping (March-April).

Additional information is needed regarding the population size, distribution and survival of the Santa Cruz Island foxes in order to decide whether captive breeding is warranted, and to determine the appropriate number of animals to bring into captivity. Such information should be made available by late September, 2001.

The island fox population on San Clemente may be declining, perhaps partly due to management actions designed to reduce predation on endangered San Clemente loggerhead shrikes. The effects of predator management on foxes should be evaluated.

Captive Breeding

Because recovery of island foxes on San Miguel and Santa Rosa Islands now depends on the success of captive breeding, we make the following findings:

Each captive breeding facility must have access to a veterinary/quarantine facility where animals may be treated. There is currently no such facility on San Miguel Island. During a 5-10 year captive breeding effort such as envisioned for the islands, there will inevitably be a need to treat animals in such a facility. Thus, a veterinary care facility similar to the one on Santa Rosa Island should be built or provided for the San Miguel captive breeding program. The facility should provide space, equipment, and supplies as recommended by the veterinary care working group.

The captive facilities on San Miguel and Santa Rosa will soon be expanded so that the captive population is large enough to annually produce an adequate number of foxes for release into the wild. The fox caretaking workload will necessarily increase with additional numbers of foxes. Adequate staffing should be provided to caretake for the expanded captive populations.

Several fox pairings on San Miguel Island have failed to produce litters in two years. The reasons for these failures are unknown. Video monitoring of captive foxes could determine whether these pairs are exhibiting breeding behavior, or whether litters are produced but pups perish prior to observation by staff. In order to accomplish this level of monitoring, the existing video camera system needs to be expanded to include four cameras per pen. This scope of coverage would allow monitoring not only of breeding behavior but also birth dates, pup fate, and neonatal care.

Failure of matings may also be due to inadvertent pairing of related animals. Genetic testing could determine relatedness for such cases, and could assist in ensuring that future pairings avoid this pitfall. Therefore, the ongoing genetic analysis of the captive fox populations should be completed prior to October, 2001, if those results are to be useful in making pairings for the 2001-2002 breeding season.

Wildfire is a potential threat to the captive populations. Until fire management actions remove the threat of wildfire, evacuation of captive foxes is a viable option for reducing the threat. Therefore, Vari-Kennels should be provided for each pen for this purpose.

Because island foxes are not well-known to the general public and there are few island foxes in North American zoos, California zoos and other wildlife educational facilities are encouraged to hold island foxes and present the conservation message for the species. The immense value of these educational opportunities warrants the continued maintenance of the current zoo population, which comprises seven males and six females, all from San Clemente Island. A breeding program should be initiated including genetic analysis and identification of suitable captive space.

The captive population in mainland zoos and on Santa Catalina Island, while less critical to recovery of their respective subspecies than the captive programs on San Miguel and Santa Rosa Islands, provide great opportunities for research on such subjects as pup development, parental behavior, feasibility of hand-rearing, pre-release conditioning, and treatment of disease and parasites.

Veterinary Care

Because the health of individual foxes is vital to the success of the current captive breeding efforts, we make the following findings:

Health concerns for island foxes include canine distemper virus and other infectious diseases, pathogenic parasites, lack of body fat, thyroid atrophy, neonatal deaths, and handling trauma.

To address and mitigate these concerns, adequate hospital facilities including the necessary staff and equipment are needed on all islands. There is also a need to standardize veterinary protocols, sample submission sites, and submission forms, and there is a need to centralize all data and develop a method for distribution of information.

A subpopulation of captive animals should be vaccinated with the canary pox virus for canine distemper, and serosurveys should be conducted on all islands to determine the risk of infectious disease. Protocols should be developed to minimize the risk of people or equipment transmitting disease among sites or islands.

Internal and external parasites need to be identified, and life cycles determined. Protocols need to be developed to minimize parasite loads in the captive facilities and to treat infested foxes. Methods need to be developed to evaluate body condition and nutritional status of individual foxes. The link between thyroid function and possible effects of PCBs needs to be investigated.

A standard manual needs to be developed for veterinary care and disease surveillance of island foxes.

THREATS TO ISLAND FOXES

We find that island fox populations are threatened or impacted by many factors (Table 1), although the relative effects of those factors are not well-known in all cases. The impacts of golden eagles and of canine distemper virus have been well established. Less well-known is the importance of other predators, such as red-tailed hawks. The influence of other canine diseases is unknown, as are the impacts of endoparasites. The latter occur in superinfections on at least one island (San Miguel), and are probably impacting individual health, but it is not known if they contribute significantly to mortality. Necropsies of foxes from all islands suggest there are some general problems with poor nutritional condition, and reduced thyroid size, but the importance of such factors, and their causes, are unknown, and warrant further investigation. Collision with vehicles remains an important mortality factor on the three southern islands which have paved roads. Up to 30 or 40 foxes have died annually from such collisions on some islands. Reduction in speed limits and clearing vegetation from the sides of roads can help mitigate this, as it has on San Nicolas Island.

The influence of competition with introduced species, such as feral cats or feral pigs, is unknown. There is mounting evidence that control or eradication measures (e.g. trapping for feral cats) may impact island foxes; on the other hand, local restrictions against cat trapping on Santa Catalina allow feral cats to inhabit island fox habitat. Domestic dogs can kill island foxes in agonistic encounters, as well as vector canine diseases.

Evidence from Santa Cruz and San Clemente islands suggests that island foxes avoid thick stands of alien grasses, and the proliferation of those grasses, or of alien fennel stands, may effectively reduce habitat available for island foxes. Habitat may also be lost to development for municipal or military purposes. Wildfires may potentially cause direct mortality, or loss of habitat.

On islands containing significant human developments and activity, the tendency for island foxes to frequent human developments, and the predilection for humans to interact with them (i.e., feed foxes), may eventually result in the mortality of those individual foxes. On San Clemente Island, the effects of predator control on island foxes are unknown, but need to be investigated. Foxes have been euthanized in the past, and are currently trapped from shrike breeding territories and held in captivity until shrikes are fledged. Foxes are also captured in traps set for feral cats. Another unknown human effect is impact to individual foxes from handling for scientific or management purposes.

The existence of island foxes in small populations, some as low as 15-25, puts them at risk of extinction from stochastic processes (e.g., normal variation in reproduction and survival, or occasional years of drought or severe weather). Some of the populations have undergone genetic bottlenecks, but the effect of such on individual health, reproduction, mortality and population persistence is unknown.

Table 1. Factors currently impacting or threatening to impact island fox populations. S = stressor currently impacting population; T = threat to population.

Factor	San Miguel	Santa Rosa	Santa Cruz	San Nicolas	Santa Catalina	San Clemente
Golden eagle predation	T	T	S			
Other predation	T	T	T	T	T	T
Canine distemper virus	T	T	T	T	T	T
Other diseases	T	T	T	T	T	T
Pathogenic parasites						
<i>Angiocalulus</i>	S					
Spirocerids	S?	T?	T?	T?	T?	
<i>Uncinaria</i>	S	T?	T?			
<i>Dirofilaria</i>	S?	S?	S?	S?		
Decreased nutritional status	T	T	T	T	T	T
Diminished thyroid size	T?			T?	T?	T?
Collision with vehicles				S	S	S
Competition with introduced species			T	T	T	T
Encounters with domestic dogs					S	
Encounters with hunting dogs			T?		T?	
Feral animal removal activities	T		T	T	T	T
Local ordinance prohibiting feral cat trapping					T	
Habitat change or succession						
Expansion of alien grasslands	S	S	S		S	S
Expansion of fennel stands			S		T	
Loss of habitat due to development					T	T
Wildfire	T	T	T	T	T	T
Predator control activities for the loggerhead shrike						S?
Interaction with humans (feeding, etc.)				T	T	T
Effects of handling for management and research	T?	T?	T?	T?	T?	T?
Genetic bottleneck	T	T	T	T	T	T
Stochastic effects on small populations	T	T	T	T	T	T?
Effects of climatic change	T?	T?	T?	T?	T?	T?

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***Appendix C Notes from Captive Breeding Working Group Meeting,
June 2001***

ISLAND FOX CAPTIVE BREEDING WORKING GROUP NOTES

June 20-21, 2001

SAN MIGUEL AND SANTA ROSA

Pair selection:

5 of the 7 offspring produced in captivity are from the same parents.

However, all 5 male pups born this year should be put in breeding situations, because it is more important initially to increase numbers now than to balance founder representation.

Genetic analysis critical to making decisions on pairings. We must get genotype information for San Miguel and Santa Rosa by the end of August.

Small group will reconvene in Sept. to review results.

Develop San Miguel vet facility

To be prepared for medical emergencies, due to the remoteness of the site, the California Department of Fish and Game regulations against removing foxes from the islands, and the time required to mobilize mainland veterinary support, a veterinary facility on-site is necessary

Evaluation of breeding success this year

Because wild canids are known to be sensitive to disturbance and may not mate, may abort or may fail to exhibit proper parental care, leading to death of pups, we recommend against any visitors or non-essential Park personnel to the breeding facilities during the months of the breeding season, February through May.

San Miguel: Improved this year

- 2 of 5 pairs produced pups.

- 1 pair included a yearling male, which may explain failure to reproduce

- The 2 other pairs each may contain members of a separated pair, which could explain the failure; the foxes in these pairs also seem most nervous and possibly stressed. We recommend that these be considered for movement to new pens depending on outcome of genetic analysis. On the other hand, for the possible pair, if genetics show them to be siblings, they should remain with their current partner for one more season before giving up on their potential to reproduce successfully.

To improve reproductive success, it is necessary to determine reasons for the failures, e.g., more comprehensive video monitoring of mating activity, parturition and early pup development and parental care.

Santa Rosa:

First complete breeding season for this facility. Good success, especially considering the young age and inexperience of most of the pairs

- 5 of 8 pairs produced pups

- 3 of the 5 litters were sired by 1-year old males
- Of the 3 pairs that did not reproduce
 - 1 pair: both were yearlings
 - 2nd pair: female reproduced last year (brought in pregnant); her partner this year may not have been her mate in the wild. Genetic analysis could tell us whether her actual mate is in the captive population
 - 3rd pair: male was yearling and female 2-year-old, so failure could have been due to his inexperience; female has chronic conjunctivitis, which may be a problem; she may also have an unidentified mate in the captive population

Santa Catalina: First year

- 2 of 3 females brought in as pairs mated in captivity and gave birth to a total of 4 pups, of which 3 survived.
- 7 females were captured during late pregnancy, which may have compromised their reproductive success; of 14 pups born to them, only 3 survived.
- An attempt will be made to capture the still free-ranging mates of the 5 unpaired females by the end of September 2001 and reunite in preparation for the next breeding season.

New Pen Locations for San Miguel and Santa Rosa

Disease and fire pose the greatest risk of catastrophic loss to the captive fox population. For those reasons, second sites should be separated at maximum practical distances and with a physical barrier (e.g., a ridge line) between the pen locations. Pens within each location should be parallel to each other and perpendicular to prevailing winds. Due to the likelihood of disease transmission among sites, we recommend decontamination of people, vehicles, food handling equipment between facilities. The team is developing a fire emergency plan. Additional staff will be needed to care for the increased number of captive foxes in the new pens.

MAINLAND CAPTIVE POPULATIONS

Santa Barbara Zoo
Utah's Hogle Zoo
Lindsay Wildlife Museum (Walnut Creek, Ca)
California Living Museum (Bakersfield, Ca)

Purposes:

Education
Research

We encourage California zoos and other wildlife educational facilities to hold island foxes and present the conservation message for the species. The value of educational opportunities warrants continued maintenance of the mainland San Clemente fox population.

Current population: 7 males (2 castrated) and 6 females

Genotyping is required to determine genetic relationships so a managed population can be possible. Even if used only for education, it is important that the genetic health of the population be maintained. Given the small founder numbers, it would be beneficial to obtain additional foxes from San Clemente, if there are injured adults or rescued pups that couldn't survive in the wild.

Similar animals from other islands could also be maintained in mainland zoos and used in education programs, although we currently do not recommend that they be included in the breeding population

Santa Barbara Zoo is assembling a husbandry manual and a list of institutions that are willing to exhibit the San Clemente Island fox.

A breeding program should be initiated following genetic analysis and identification of suitable captive space.

Research Opportunities

Mainland zoos:

Santa Barbara Zoo: 3.2

Utah's Hoagie Zoo: 2.2

Lindsay Wildlife Museum (Walnut Creek, Ca): 1 (castrated).0

California Living Museum (Bakersfield, Ca): 1 (castrated).2

- Gonadal steroid data from fecal samples from females not with males
- Monitor temperature and humidity data in nest box
- Evaluate desensitizing protocol to restraint for pregnancy ultrasound (Santa Barbara)
- Collect single blood samples from pregnant females to evaluate relaxin assay kit for pregnancy diagnosis in the species
- Establish pup developmental parameters norms (tooth eruption and growth patterns; body weight and measurements; dates of eye- and ear-opening; first nursing, mobility, interaction with siblings, etc.)
- Arrange for milk analysis
- Establish parental behavior norms (check with Tarrren Waggener at Ft. Worth who developed ethogram for swift fox).
- Develop a hand-rearing protocol, if any pups have to be hand-raised, using fennec fox protocol as a model.
- Evaluate stress situations by fecal hormone analysis, e.g., collect fecal samples before, during and after handling or other potentially stressful procedures (e.g., mowing around pens) or events (e.g., tours, storms) to document whether the animals acclimate to the stressor.

Santa Catalina Captive Facility:

- Gonadal steroid data from fecal samples from females not with males
- Monitor temperature and humidity data in nest box
- Evaluate pre-release conditioning protocols and release protocols
- Establish pup developmental parameters norms (tooth eruption and growth patterns; body weight and measurements; dates of eye- and ear-opening; first nursing, mobility, interaction with siblings, etc.)
- Measure air movement in den boxes or modify den boxes to be less drafty.
- Evaluate stress situations by fecal hormone analysis, e.g., collect fecal samples before, during and after handling or other potentially stressful procedures (e.g., mowing around pens) or events (e.g., tours, storms) to document whether the animals acclimate to the stressor.

Summary Funding Needs

The team has determined that the following items are essential for the successful management of the captive fox populations at San Miguel and Santa Rosa:

- Veterinary facility on San Miguel
- Additional staff for additional pen sites
- More video camera systems with infrared arrays and solar panels to achieve 4 per pen essential to monitor breeding activity, birth, neonatal care (San Miguel currently has priority).
- Vari-Kennels for each pen for management purposes and for evacuation in case of fire

Appendix D Standard Operating Procedure for Island Fox Care

Appendix E Diet Sheet for Captive Island Foxes

