PETITION TO LIST 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*)
Santa Catalina Island fox (*U. l. catalinae*)

AS ENDANGERED SPECIES

Center for Biological Diversity
Institute for Wildlife Studies
June 1, 2000

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Notice of Petition

Pursuant to the Endangered Species Act of 1973, 16 U.S.C. §§ 1531 *et seq.*, the Center for Biological Diversity and the Institute for Wildlife Studies hereby formally petition the United States Secretary of Interior and the United States Fish and Wildlife Service to list the San Miguel Island fox (*U. l. littoralis*), Santa Rosa Island fox (*U. l. santarosae)*, Santa Cruz Island fox (*U. l. santacruzae*), and the Santa Catalina Island fox (*U. l. catalinae*) as "endangered" throughout its range. We submit this petition as an interested party under 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14.

In accordance with the Endangered Species and the Administrative Procedures Act, the Center also requests that critical habitat be designated concurrently with the final listing rule.

_____ Date this ___ day of May, 2000

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The Center for Biological Diversity is dedicated to protecting imperiled species and their habitats in western North America and the Pacific Islands. Combining scientific research, public organizing and strategic litigation, the Center has attained Endangered Species Act protection for over 100 species and has protected millions of acres of land and thousands of miles of rivers.

The Institute for Wildlife Studies was incorporated in 1979 to contribute to the scientific understanding and conservation of wildlife and their habitats. The Institute has been integrally involved with efforts to protect and recovery the island fox, San Clemente loggerhead shrike, and the San Clemente sage sparrow.

Executive Summary

Though weighing less than 5.5 pounds, the island fox (*Urocyon littoralis*) is a top level predator of great importance to the Channel Islands ecosystem of southern California. It is the largest native mammal, and the largest native terrestrial predator on the islands. It is the only carnivore endemic to the state of California. Its extinction would be a tremendous loss to California's unique natural heritage and the ecological balance of the Channel Islands.

The island fox inhabits the six largest Channel Islands, with each island supporting a unique subspecies (see Table 1). Four of those subspecies have suffered dramatic declines in recent years and will likely become extinct if immediate and aggressive conservation action is not taken: the San Miguel Island fox, Santa Rosa Island fox, Santa Cruz Island fox, and the Santa Catalina Island fox. The Center for Biological Diversity and the Institute for Wildlife Studies herein petition to list those four subspecies as endangered under the U.S. Endangered Species Act. While we have concerns about the long-term status of the two remaining subspecies (the San Nicolas and San Clemente Island foxes), and believe they require careful monitoring, they are relatively secure at this time and are not being petitioned at this time.

Table 1. Four Island fox Subspecies Being Petitioned for Endangered Species Act Protection

ISLAND	SUBSPECIES	SUBJECT OF THIS PETITION
NORTHERN CHANNEL ISLANDS		
San Miguel	*U. l. littoralis*	**U**
Santa Rosa	*U. l. santarosae*	**U**
Santa Cruz	*U. l. santacruzae*	**U**
SOUTHERN CHANNEL ISLANDS		
San Nicolas	*U. l. dickeyi*	
Santa Catalina	*U. l. catalinae*	**U**
San Clemente	*U. l. clementae*	

Mainland foxes colonized the Channel Islands 16,000 years ago. The northern Channel Islands were a single super-island at that time due to lower ocean levels during the Pleistocene. Santa Cruz Island split off about 11,500 years ago, followed by the separation of San Miguel and Santa Rosa islands some 2,000 years later. Foxes from San Miguel Island were likely brought to the three southern Channel Islands by Native Americans 2,200 to 4,300 years ago. The island fox evolved into a new and unique subspecies on each island as it became genetically isolated from foxes on other islands.

The San Miguel island fox has dropped from a historic population of about 450 to just 50 in 1998, and to 15 in 1999. Fearing the extinction of the subspecies, biologists recently placed 14 foxes in protective pens. Just one wild fox remains on the island. Nightly capture rates of the Santa Rosa island fox have dropped from 36% in 1972, to 8% in 1998, to just 2% in 1999. Similar declines have occurred on Santa Cruz and Santa Catalina islands. Without immediate conservation intervention, including protection from predation and disease, intensive research into the causes of decline, and establishment of adequate federal funding, California may well experience the extinction of one its most unique and beautiful native species.

The causes of decline are not clear and may involve several, possibly interconnected factors. The San Miguel and Santa Cruz subspecies are suffering from high predation rates by golden eagles. Historically, golden eagles did not occur on the Channel Islands. Because bald eagles are highly territorial with respect to other eagles, their extirpation due to DDT and other factors opened up a niche for golden eagle colonization. Golden eagles have also benefitted by the introduction of exotic pigs to the islands. While bald eagles primarily prey on fish and are thus not a threat to the island fox, golden eagles prey extensively on land mammals, including feral pigs and island foxes. Efforts are underway to restore bald eagles, relocate golden eagles, and remove feral pigs. If completed, these efforts will greatly reduce predation pressure on the island fox.

The Santa Catalina subspecies' catastrophic decline appears to be linked to canine distemper. This disease was likely contracted from domestic dogs despite regulations designed to prohibit or limit dogs on many of the islands. All island fox populations are impacted by the past degradation of native habitats by introduced livestock and game species.

Systematics

Species Description

A diminutive relative of the mainland gray fox (*Urocyon cinereoargenteus*), the island fox (*U. littoralis*) is found on the six largest of California's eight Channel Islands. The island fox is distinguished from the gray fox by its darker pelage and its smaller size (Collins 1982). Most linear measurements of island foxes are 25% smaller than those of the gray fox. The tail is conspicuously short. Island foxes display sexual size dimorphism, with males being larger and heavier than females (Collins 1982, 1993).

Taxonomy

The taxonomic validity of *U. littoralis* is not in question. The species has long been recognized as distinct from the mainland gray fox (Collins 1982, Moore and Collins 1995). The Gray fox and Island fox are the only two members of the genus *Urocyon*.

Six subspecies of island fox are recognized (Hall 1981): *U. l. littoralis*, *U. l. santarosae*, *U. l. santacruzae*, *U. l. dickeyi*, *U. l. clementae*, and *U. l. catalinae*.

Distribution and Evolution

Each of the six largest Channel Islands is inhabited by a single subspecies of island fox (Table 1) (Hall 1981, Collins 1993). Morphologically, the species exhibits inter-island variability in size, nasal shape and projection, and the number of tail vertebrae (Collins 1982). Archeological and geological evidence suggests that foxes dispersed over water from the mainland and first arrived on the northern Channel Islands more than 16,000 years ago, but dispersed to the southern islands as recently as 2,200 – 4,300 years ago. Native Americans are believed to have transported Island foxes to the southern Channel Islands (Collins 1982, 1991).

Genetic evidence supports the separation of the species into six distinct subspecies, and confirms the pattern of dispersal suggested by archeology and geology. A study of genetic variability in DNA restriction fragments in Island foxes (Gilbert *et al.* 1990) revealed that inter-island variability was greater than intra-island variability. Phylogeny based upon restriction fragment variability supports the geological evidence for the sequence of isolation for each island, and each population. At the time of colonization from the mainland, the northern Channel Islands were coalesced into one landmass ("Santarosae") due to lower sea levels during the Pleistocene. Santa Cruz separated from the other northern islands first, about 11,500 years ago, followed by the separation of San Miguel and Santa Rosa about 9,500 years ago. Together with the fossil record, restriction fragment evidence indicate that San Clemente was the first southern Channel Island colonized, probably by immigrants from San Miguel. Dispersal then occurred from San Clemente to San Nicolas and Santa Catalina.

Figure 1. Distribution of Island fox Subspecies on the California Channel Islands.

Island forms generally have less genetic variability than their mainland counterparts, and Island foxes are no exception. The mainland gray fox

was found to be more variable in morphology, allozymes, mitochondrial DNA, and hypervariable minisatellite DNA than Island foxes (Wayne *et al.* 1991a). The smallest Island fox populations, San Miguel and San Nicolas, showed the least genetic variability, and the San Nicolas population was actually monomorphic in allozyme, hypervariable minisatellite DNA, and mitochondrial DNA, which is highly unusual among mammals. This lack of variability could be attributed either to extensive inbreeding, or bottlenecking resulting from low population densities (George and Wayne 1991). On San Miguel and San Nicolas, the species has apparently existed for thousands of years at low population sizes, and low effective population sizes (150-1000), with low genetic variability (Wayne *et al.* 1991a, 1991b). The Santa Rosa and San Miguel populations were shown to be closely related.

Significance

Though individuals weigh less than 2.5 kg, island foxes are the largest native mammal, and the largest native terrestrial predator on the Channel Islands. The only other mammalian predators present are the island spotted skunk (*Spilogale gracilis amphiala*) on Santa Cruz and Santa Rosa Islands, and feral cats (*Felis catus*) on the three southern Channel Islands (Moore and Collins 1995).

Island foxes are the only carnivore whose distribution is restricted to the state of California.

Natural History

A complete account of the species is given by Moore and Collins (1995).

Habitat Use and Home Range

Island foxes occur in virtually every habitat on the Channel Islands and feed on a wide variety of prey (Moore and Collins 1995). They occur in valley and foothill grasslands, southern coastal dune, coastal bluff, coastal sage scrub, maritime cactus scrub, island chaparral, southern coastal oak woodland, southern riparian woodland, Bishop and Torrey pine forests, and coastal marsh. habitat types. Crooks and Van Vuren (1995) found Island foxes to prefer fennel grasslands and to avoid ravines and scrub oak patches on Santa Cruz Island.

Island fox home range size varies by habitat type, season and sex of the animal (Fausett 1982, Laughrin 1977, Crooks and Van Vuren 1995, Garcelon 1999, Roemer 1999). Recorded home range estimates range from 23.5 ha in mixed habitat (Crooks and Van Vuren 1995) and 47.5 ha in grassland habitat (Roemer 1999) on Santa Cruz, to 76.5 ha in canyons on San Clemente (Garcelon 1999).

Food Habits

A comprehensive treatment of Island fox diet is found in Moore and Collins (1995).

The island fox diet includes a wide variety of plant and animal materials (Collins 1980; Laughrin 1973,

1977, Crooks and VanVuren1995; Moore and Collins 1995). Island foxes forage opportunistically on any food items encountered within their home range. Selection of food items is determined largely by availability, which varies by habitat and island, as well as seasonally and annually. Principal foods eaten include mice, ground nesting birds, arthropods, and fruits.

Island foxes prey on native deer mice (*Peromyscus maniculatus*), as well as introduced house mice (*Mus musculus*), rats (*Rattus rattus*) and ground squirrels (*Spermophilus beecheyi*) on Santa Catalina Island. In addition to small mammals, Island foxes feed on a wide variety of native plants including the fruits of *Arctostaphylos*, *Comarostaphylis*, *Heteromeles*, *Opuntia*, *Prunus*, *Rhus*, *Rosa*, *Solanum* and *Vaccinium* (Moore and Collins 1995). Arborescent fruiting shrubs due not occur on San Miguel Island, where foxes rely more on the fruits of sea-fig, *Carpobrotus chilensis*. Foxes also feed on a wide variety of insect prey and appear to forage opportunistically, taking insects in proportion to their seasonal and annual availability (Moore and Collins 1995). At certain times of the year foxes feed heavily on orthopterans (Crooks and VanVuren1995; Moore and Collins 1995).

Social Organization

Recent results from a study on Santa Cruz Island indicate that island foxes are distributed as socially monogamous pairs occupying discrete territories (G. Roemer 1999). Territory size and configuration are dependent on landscape features, resource distribution, and fox density. Island fox territory size on Santa Cruz Island varied from 0.15 to 0.87 km^2 and averaged 0.55 km sq. during a period of moderate to high fox density (7 foxes/km sq.). On San Clemente Island, fox territory size averaged 0.75 km^2 (n = 11) (Garcelon 1999)**.** On Santa Cruz Island territory configuration changed after the death and replacement of paired male foxes, but not after the death and replacement of paired females or juveniles, indicating that adult males are involved in territory formation and maintenance (Roemer 1999). Despite being socially monogamous and territorial, island foxes are not strictly monogamous. Four of 16 offspring whose parents were identified by paternity analysis were a result of extra-pair fertilizations (Roemer 1999). All extra-pair fertilizations occurred between foxes from adjoining territories. Although canids are typically thought of as being genetically monogamous, recent research on Island foxes, and other canids, are revealing more flexible breeding strategies than previously thought for the family. Based on the capture of adult male foxes in the same traps with pups, it is surmised that males contribute to the responsibilities of rearing offspring (Garcelon *et al.* 1999).

Reproduction

Although island foxes can breed at the end of their first year (Laughrin 1977), most breeding involves older animals. Coonan *et al.* (1998) found that only 16% of juvenile females bred over a five year period on San Miguel Island, in contrast to 60-80% of older females.

Island foxes generally breed from January through March, when courtship and pair formation occur (Moore and Collins 1995). Most breeding occurs in late February and early March, and the gestation period is estimated to be from 50 to 53 days. Parturition usually occurs from the end of April through early May (Laughrin 1977). Island fox pups are born in dens, which are usually not excavated

(Laughrin 1973). Litter size ranges from one to five (Moore and Collins 1995). Average litter size on San Miguel Island from 1993 to 1997 was 2.2 (Coonan *et al.* 1998). Pups are seen foraging with their parents outside the den by mid-summer, and generally disperse away from their natal territories by winter.

Survival and Mortality

The maximum life span for island foxes in the wild is eight to 10 years (Coonan *et al.* 1998), although four to six years is a more typical life span (Collins 1982). Long-term demographic studies show that pup and adult survival vary on different islands (T. Coonan, D. Garcelon and G. Roemer, unpubl. data). Average pup survival rates on San Clemente, Santa Cruz and San Miguel were 0.52, 0.30., and 0.39, respectively (see Table 2). Average adult survival rates were 0.69, 0.42, and 0.52.

Mortality factors for Island foxes are not precisely known. Collision with motor vehicles is an important mortality factor on San Nicolas and San Clemente Islands (Moore and Collins 1995, Garcelon 1999) (Table 2). On San Nicolas Island, up to 40 foxes are killed by vehicles annually (G. Smith, U. S. Navy, personal communication). Recent studies have identified golden eagle predation as a significant mortality factor on at least two islands, Santa Cruz and San Miguel (Roemer *et al.* in prep., T. Coonan, unpubl. data), and it is likely the cause of the population decline on Santa Rosa Island. Canid diseases are a possible mortality factor (Garcelon *et al.* 1992), as is heartworm (*Dirofilaria immitis*), a common canid parasite found in four of six Island fox populations (Roemer *et al.*, in press). A recent catastrophic population decline of foxes on Santa Catalina Island has been attributed to canine distemper virus (Timm *et al.* 2000).

Table 2. Survival rates and primary causes of mortality.

	Annual Adult Survival	Annual Pup Survival	Primary Cause of Known Mortality
NORTHERN ISLANDS			
San Miguel (*U. l. littoralis*)	52%	39%	Golden eagle predation
Santa Rosa (*U. l. santarosae*)			Golden eagle predation?
Santa Cruz (*U. l. santacruzae*)	42%	30%	Golden eagle predation
SOUTHERN ISLANDS			
San Nicolas (*U. l. dickeyi*)			Automobile collision
Santa Catalina (*U. l. catalinae*)			Canine distemper
San Clemente (*U. l. clementae*)	69%	52%	Automobile collision

Competition With Other Species

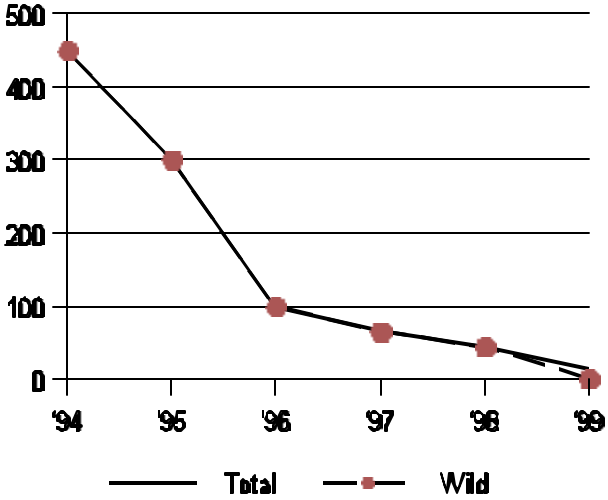
Potential competitors of Island foxes are feral cats on the southern islands, and the island spotted skunk (*Spilogale gracilis amphiala*) on Santa Cruz and Santa Rosa islands. Crooks and Van Vuren (1995) found substantial overlap between skunks and foxes in spatial, dietary and temporal utilization of resources on Santa Cruz Island, and concluded that competition occurred between the two species despite some differences in habitat use, diet and circadian activity. Spotted skunks appear to have increased in abundance concurrent with the decline of the Island fox. On one trapping grid on Santa Cruz Island 54 skunks were captured where only 4 foxes were found (G. Roemer, Institute for Wildlife Studies, pers. comm.). On Santa Rosa Island almost five times as many skunk captures were recorded compared to foxes (T. Coonan, National Park Service, pers. comm.).

Population Status and Trends

San Miguel Island

Channel Islands National Park has conducted population monitoring of Island foxes since 1993 (Schwemm 1995,1996, Austin 1996, 1998). Data from the Park's monitoring program indicates that the Island fox population on San Miguel Island has declined substantially, from a historical high of around 450 adult foxes to less than 50 in 1998 (Figure 2) (Coonan *et al.* 1998, Coonan *et al.*, in press). Due to the threat to the population from golden eagle predation (see below), 14 foxes (10 females and 4 males) were brought into captivity and placed in breeding/holding pens to provide for their protection. Only one other fox (a female) is known to be present in the wild on San Miguel Island at this time. Although other island fox populations have shown natural fluctuations over time, the range of fluctuation on San Miguel is greater than recorded ranges from other island populations (Roemer *et al.* 1994).

Figure 2. San Miguel Island Fox Population Trend.



The decline affected both older individuals and pups. Older foxes (Age Classes 3 and 4) virtually disappeared from the sampling grids by 1998. Pup survival also declined over the study period, with virtually no pups surviving from 1996 to 1998. Coonan *et al.* (1998) listed three possible causes for the decline: 1) the effects of weather on food availability; 2) disease or parasites; and 3) predation. Changes in food availability were ruled out as a factor because deer mouse (*Peromyscus maniculatis*) populations did not decline over time on San Miguel Island.

Canine diseases were thought to be a possible factor in the decline due to the susceptibility of Island foxes to canine diseases. Foxes on San Miguel tested for exposure to canine diseases were shown to have antibodies for canine parvovirus (30%) and canine adenovirus (96%) (Garcelon *et al.* 1992). However, recent serologic surveys do not suggest that canine disease was a factor in the observed decline on San Miguel Island. Fox blood samples collected in 1994, 1995 and 1997 were tested for exposure to five potentially fatal canine diseases. The observed population decline was not associated with changes in seroprevalence (percent of blood samples testing positive) for canine diseases over the period of decline (Coonan *et al.* 1998). Foxes tested negative for canine distemper and two strains of leptospirosis. One fox tested positive for parvovirus in 1994. Annual seroprevalence to canine adenovirus on San Miguel ranged from 89-100%, similar to previous serologic studies. Although canine adenovirus can cause infectious canine hepatitis and may be resident in the San Miguel Island fox population, as in other Island fox populations, its role in the observed fox decline is unknown.

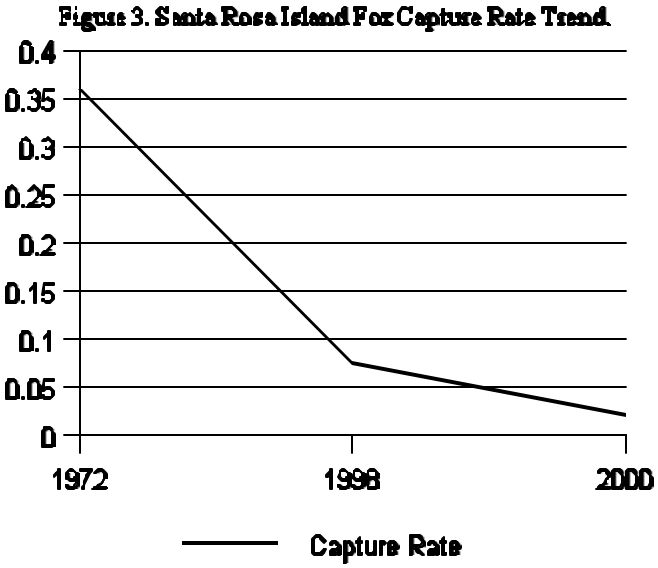
Predation by golden eagles has been identified as the primary mortality factor for foxes on San Miguel (G. Roemer *et al.* in prep; T. Coonan unpubl. data). From November 1998 to March 1999, four of eight radio collared Island foxes on San Miguel were killed by golden eagles. Each carcass had been dismembered and consumed in a manner typical of golden eagles (G. Roemer, Institute for Wildlife Studies, personal communication). A feather found at the kill site of the first carcass was positively identified as a contour feather from an immature golden eagle (T. Coonan *et al.* in prep). Park staff have recorded weekly observations of one to two golden eagles hunting on San Miguel Island since November 1998 (T. Coonan, unpubl. data). Given the high rate of predation on collared foxes, it is likely that uncollared foxes were also predated during that time period.

Santa Rosa Island

Island foxes Santa Rosa Island have declined dramatically in recent years. Although a regular island fox population monitoring has not been conducted on Santa Rosa Island, a significant population decline is thought to have occurred. This contention is supported both by anecdotal information and recent Island fox survey data. Until 1998, Santa Rosa island was home to a commercial cattle ranch that had operated since about the turn of the century. The ranch manager, who had lived on the island for approximately 50 years, observed in 1998 that Island foxes appeared to be more scarce than at any other time since he had been on the island (personal communication to D. Garcelon, Institute for Wildlife Studies). Channel Islands National Park staff have also noted the lack of foxes in recent years, and have observed more islands spotted skunks than foxes. As recently as 1996, foxes were more commonly observed than skunks (T. Coonan, National Park Service, personal communication).

Comparison of trapping data for island foxes on Santa Rosa Island from 1972 (Laughrin 1980) with data collected in 1998 and 2000 (D. Garcelon and G. Roemer, unpubl. data) indicate a recent population decline. For all of these studies, foxes were captured in box traps along survey transects. Capture rate, or the number of individual foxes captured per total number of trap-nights, was 35.8% in 1972, but only 7.6% in 1998 (n = 132 trap nights) and 2.2% in 2000 (449 trap nights) (see Figure 3).

As Santa Rosa Island lies between two islands (Santa Cruz and San Miguel) that are thought to have suffered catastrophic declines due to golden eagle predation, the cause of the decline on Santa Rosa Island is likely the same. Golden eagles have been observed on Santa Rosa Island regularly since 1995 (T. Coonan, National Park Service, unpubl. data). Carcasses from the annual culling of mule deer and elk during a commercial hunt program may attract golden eagles. Island foxes on Santa Rosa Island are particularly vulnerable to aerial predators, as 80% of the island is comprised of alien annual grasslands (Clark *et al.* 1990) which provide no cover from aerial predators.



Little is known about the effect of disease and parasites on island foxes on Santa Rosa Island. There may be a high incidence of heartworm (*Dirofilaria immitis*) in island foxes on Santa Rosa Island (Roemer *et al.*, in press). Six adult island foxes sampled in 1998 tested positive for antigen to canine heartworm. Heartworm may have been present on the island for at least a decade, as 87% of 38 Island foxes blood samples from 1988 tested positive for heartworm antibodies. Blood samples collected from 34 foxes sampled in 1988 tested positive for antibodies for canine adenovirus (96%), canine parvovirus (30%), canine herpesvirus (12%), and toxoplasmosis (12%) (Garcelon *et al.* 1992). No antibodies were detected for canine distemper virus, canine coronavirus, or two types of leptospirosis.

The Santa Rosa Island fox population has dropped from about 2,000 to less than 100 in the last five years (Santa Catalina Island Conservancy 2000).

Santa Cruz Island

Population survey of Island foxes conducted by Laughrin (1980) between 1973 and 1977 resulted in high capture success (49%-78%) on Santa Cruz Island (n = 819 trap nights). Between 1991 and 1993 Crooks (1994) surveyed for spotted skunks (*Spilogale gracilis amphiala*) and Island foxes and had 22% trap success for foxes in his two study areas. Between 1993 and 1995 Roemer (1999) intensively studied foxes on the west end of Santa Cruz Island, and captured 63 foxes 874 times during 2,520 trap nights (34.7% trap success). By 1998, 756 trap nights resulted in only a 2.9% trap success (Roemer 1999). On a trapping grid operated on at Fraser Point on the West end of Santa Cruz Island, no foxes were captured in either 1998 or 1999, where 63 individuals had been captured on that grid between 1993 and 1995 (G. Roemer, Institute for Wildlife Studies, personal communication). It is estimated that fewer than 100 foxes remain on Santa Cruz Island (G. Roemer, Institute for Wildlife Studies, personal communication).

In a recent study of Island foxes on Santa Cruz Island, predation by golden eagles (*Aquila chrysaetos*) was identified as the cause of death for 21 of 29 Island fox carcasses (Roemer 1999). Signs of predation on these carcasses included talon wounds, holes in the skulls, golden eagle feathers at the carcasses, and carcasses exhibiting damage typical of a raptor feeding pattern. Helicopter and ground surveys conducted during 1999 suggest between 7-15 golden eagles are occupying the northern Channel Islands chain, with the possibility of four breeding pairs on Santa Cruz Island. The U.S. Park Service is currently attempting live trapping and removal of golden eagles from the Northern Channel Islands in order to reduce the threat to the remaining fox populations.

Based on the presence of antibodies, foxes on Santa Cruz Island have previously been exposed to a variety of canine diseases (Garcelon *et al.* 1992). Blood samples collected from 29 foxes sampled in 1988 tested positive for antibodies for canine herpesvirus (10%), canine parvovirus (59%), canine coronavirus (7%), *Leptospira interogans* serovar *interohaemorrhagiae* (14%), and *Toxoplasma gondii* (3%) (Garcelon *et al.* 1992). No antibodies were detected for canine distemper virus or canine adenovirus. The prevalence of antigen for heartworm in Santa Cruz Island foxes was 83% in 1988 (n = 30) and 58% in 1997-98 (n = 26) (Roemer *et al.*, in press).

With the continued threat from golden eagles, and the already low population size, intensive management such as captive breeding and release may be necessary to assist in the recovery of the population.

San Nicolas Island

During surveys using box traps along transects, capture success went from 72% in 1971 to 4% and 4.7% for 1974 and 1977, respectively (Laughrin 1980). While these data were based on relatively few trap nights (40, 52, and 75 trap nights for 1971,1974, and 1977), there is a suggestion that the population may have declined after 1971. Between 1980 and 1986, the fox population increased significantly, although estimates for the island-wide population estimate varied widely (Kovach and Dow 1981,1985; Kovach 1981,1982). During a brief trapping effort in 1998, capture success was high (41.3%; n = 80 trap nights) and fox sign was very evident on island (G. Roemer, Institute for Wildlife Studies, personal communication).

In a 1988 serologic survey, 46 foxes on San Nicolas Island were sampled and found to have antibodies to canine adenovirus (72%), canine parvovirus (7%) and *Toxoplasma gondii* (7%) (Garcelon *et al.* 1992). There was a significant increase in the prevalence of antigen for heartworm from 1988 (25%; n = 32) to 1998 (78%; n = 30) (Roemer *et al.* in press).

Santa Catalina Island

The Island fox population on Santa Catalina Island has been studied only intermittently over the past 30 years. Early status surveys by Laughrin (1980) and Propst (1975) suggested low population densities of island fox on Santa Catalina compared to other Island fox populations. In 1989 and 1990 the Institute for Wildlife Studies conducted a study to examine the status of Island foxes concurrently on Santa

Catalina and San Clemente islands (Garcelon *et al.* 1991). During this study Island fox capture success on the three established trapping grids on Catalina Island ranged from 10.4% in low fox density areas to 31% in high density areas (Garcelon *et al.* 1991). In 1998, fox trapping was conducted in selected areas of Catalina Island to obtain serum samples to test for the presence of antigen to heartworm (Roemer *et al. in press*). During this sampling effort, 78 trap nights resulted in the capture of 20 foxes (26% capture success). This capture success was similar to what has been recorded for healthy fox populations on the northern Channel Islands (Kovach and Dow 1985, Roemer *et al.* 1994, Coonan *et al.* 1998), and on San Clemente Island (Garcelon 1999).

Starting in early 1999, personnel engaged in natural resource activities on Santa Catalina Island reported a dramatic decrease in the number of island foxes sightings. By the summer of 1999 staff of the Institute for Wildlife Studies, who are out in the field on a regular basis during crepuscular and nighttime periods, reported seeing foxes only on the west end of the island. Concurrent with this lack of observations of foxes themselves, was a subjective decrease in the occurrence of fox sign (i.e. scat, tracks) along roads and trails as well as a decrease in the incidence of hearing fox vocalizations.

Between November 1999 and April 2000, surveys were conducted across Santa Catalina Island to determine the demographics of the remaining animals. On the portion of the island east of the island's isthmus (approximately 83% of the island), 10 animals were captured during 1,046 trap nights (0.9% trap success). On the remainder of the island, 50 individuals were captured during 137 trap nights (36.5% traps success).

Two foxes captured from the eastern portion of the island had antibody levels indicating a previous exposure to canine distemper virus (CDV). No animals recovered from the West End showed serologic evidence for exposure to CDV. The apparently healthy foxes trapped on the West End have no other evidence of disease. However, as the West End only makes up only 17% of the island's land area, foxes present on this portion of the island comprise only a small percentage of the original fox population. Furthermore, as these foxes have no antibodies to CDV, they remain vulnerable to contracting the disease.

One fox that had been found dead during the summer of 1999 was examined at the UC Davis Veterinary Medical School where histopathological analysis revealed inclusions bodies consistent with CDV. Further immunohistochemical analysis performed at Cornell University confirmed the inclusion bodies to be canine distemper virus (Timm *et al.* 2000).

The extremely low capture rates exhibited during our recent fox trapping efforts on the eastern portion of the island are similar to those reported for fox populations undergoing catastrophic declines on the northern Channel Islands (Garcelon, pers. obs.; Coonan *et al.* 1998; Roemer 1999). Reduced capture success and changes in the overall population estimates were precursors of the population declines noted on the northern Channel Islands.

The discovery of two foxes with antibodies to canine distemper virus and a dead fox with the presence of virus confirm the occurrence of the disease agent in the population. The following points further support CDV as the cause of the decline: 1) previous serologic surveys of all of the fox populations resulted in no confirmed exposure to the virus (Garcelon *et al.* 1992), suggesting that false positive results are unlikely and that the Santa Catalina fox population had no natural immunity to this disease, 2) the apparent speed with which the population decline occurred on the island would be consistent with an outbreak of canine distemper, which is a highly contagious disease with 90% fatality rate in dogs (Gorham 1966), and 3) the prey base of the fox has not likely catastrophically declined, as feral cats feed on similar prey items (e.g., rodents, reptiles) and several have been captured in good health.

The current very low population size of Island foxes on the eastern 83% of the island will likely mandate very active management, such as captive breeding and release, in order for the population to recover. The narrow isthmus between the more densely populated area on the west end of the island, and the presence of a human community at that isthmus, will likely reduce natural emigration from the west end to the eastern portion of the island. This is also likely the reason that the CDV did not infect the animals on the west end of the island.

San Clemente Island

In 1972 Laughrin (1980) found high trap success while running survey transects for Island foxes on San Clemente Island. He reported a 52% trap success (n = 384 trap nights) over four trapping periods. Starting in 1988, a long-term demographic study of the Island fox involving annual trapping on three large grids was initiated on San Clemente Island (Garcelon 1999). Over the 10-year period between 1988-1997, trap success was 27.7% (n = 13,560 trap nights) across all grids for all years. Island-wide population estimates extrapolated from densities calculated from the trapping grids ranged from 613-901 individuals over the 10-year period (Garcelon 1999). However, the method used to determine density estimates based on mark-recapture and inter-trap movements by foxes may be positively biased, and therefore these population island-wide population estimates may be inflated by 20-40% (Garcelon 1999). Running 5-year averages suggest that the fox population on San Clemente Island may have declined by approximately 20% between the first and second five-year periods of this investigation.

Based on the presence of antibodies, foxes on San Clemente Island have previously been exposed to a variety of canine diseases (Garcelon *et al.* 1992). Blood samples collected from 42 foxes sampled in 1988 tested positive for antibodies for canine herpesvirus (2%), canine adenovirus (88%), canine parvovirus (50%) and *Toxoplasma gondii* (26%) (Garcelon *et al.* 1992). No antibodies were detected for canine distemper virus, canine coronavirus, or two serovars of *Leptospira interogans*.

In 1999 the US Navy, who owns and operates a military installation on San Clemente Island, began a program which involved removal of Island foxes in areas occupied by the endangered San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*). Island foxes captured in areas occupied by nesting shrikes, or in areas where shrikes were being released into the wild, were either captured and shipped

off the island to zoological institutions, or were euthanized. This practice was later changed to allow foxes to be removed from the wild and temporarily held in captivity until the fledgling shrikes were no longer vulnerable to ground predators. While this practice reduced the number of foxes removed from the population, lactating females were likely separated from their pups at the time they were brought into captivity, and therefore productivity was affected in all areas where shrike protection was implemented.

Listing Factors

Section 4(a)(1) of the Endangered Species Act (16 U.S.C. 1531 et seq.) and regulations (50 CFR part 424) promulgated to implement the listing provisions of the Act set forth general listing criteria. If a species' existence is imperiled by one or more of the following five factors, it must be listed as "threatened" or "endangered".

PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

San Miguel Island: All of Santa Rosa Island is owned by the federal government and managed by the U.S. Park Service. The island was historically used for grazing of sheep, cattle, and horses (Johnson 1980). From the mid 1940s to the mid-1950s the island was used as a bombing range by the military. As the island supported a large population of Island foxes prior to the recent decline (Coonan *et al.* 1998), and no destruction or modification of habitat has occurred, there should be no barriers with respect to habitat quality for recovery of Island foxes on this island.

Santa Rosa Island: All of Santa Rosa Island is owned by the federal government and managed by the U.S. Park Service. The island has been used for over a century for grazing of domestic cattle and other livestock. There are also large numbers of both introduced mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) resident on the island that are used to support a commercial hunting program. The island also supported a large population of feral pigs, which were eradicated by 1993. While habitats have likely changed dramatically from the pre-grazing period, foxes were reportedly in reasonable numbers on the island prior to the early to mid- 1990s. All cattle have been removed from Santa Rosa Island and the Park Service is engaged in long-term habitat restoration programs.

Santa Cruz Island: All of Santa Cruz Island is managed either by the U.S. Park Service or The Nature Conservancy, a private conservation organization (see Table 4). Years of overgrazing by feral sheep *(Ovis aries*) on Santa Cruz Island caused significant impacts on the island's native habitat (Schuyler 1993, Klinger *et al.* 1994, Wehtje 1994). While sheep have recently been removed from the island, the affects of the overgrazing on the island's habitats will likely be evident for many years. Additional impacts to the island's vegetation have been caused by the introduced feral pigs (*Sus scrofa*) (Peart *et al.* 1994). It is unlikely the impact of these grazing activities have contributed the

decline of the fox in recent years. However, degradation across a variety of habitats has likely reduced the carrying capacity of the island for foxes compared to historic times.

San Nicolas Island: San Nicolas Island is owned by the federal government and managed by the US Navy. It is operated as a military installation for a variety of purposes. Starting around the mid-1800s, the island was used for sheep ranching (O'Malley 1994). The U.S. Navy took control of the island in 1933, and it is currently used as a military base for communications and tracking. The island has an active airfield and approximately 200 military and civilian personnel. There are both large seabird and marine mammal rookeries that are protected and actively managed by the Navy's natural resources program. Expansion plans for Navy activities on the island that may affect the quality or quantity of available fox habitat are unknown at this time.

Santa Catalina Island: The majority of Santa Catalina Island (87%) is owned by the Santa Catalina Island Conservancy and remains primarily undeveloped. The island has suffered from many years of overgrazing by both domestic, introduced, and feral livestock, including goats (*Capra hircus*), pigs, mule deer, bison (*Bison bison*), and blackbuck antelope (*Antilope cervicapra*) (Coblentz 1980). Goats have been almost completely removed from the island by the end of 1999, and the Catalina Conservancy is actively working on the complete removal of feral pigs from the island. In areas where feral goats have been removed ground cover has significantly increased, although plant species comprising the increased cover are largely exotic species (Laughrin *et al*. 1994). Development on the island is almost exclusively confined to areas around the City of Avalon, the community of Two Harbors, and two ranches (Middle Ranch and Rancho Escondito). The island is a major tourist destination, catering to recreational boating, diving, biking, hiking, camping, and visitors to the City of Avalon. The island has a year round resident population of approximately 3,000 people.

San Clemente Island: San Clemente Island is owned by the federal government and managed by the US Navy. It is operated as a military installation for a variety of purposes. There are approximately 300 military and civilian personnel regularly occupying the island. The island is one of only two locations in the Pacific where ships can obtain certification for ship-to-shore artillery prior to deploying overseas. Two primary target areas exist on the south end of the island within what is referred to as the Shore Bombardment Area (SHOBA). A variety of tenant commands use the island for training. There is an active airfield, a Navy SEALS training camp, a Tomahawk Cruise Missile testing area, radar installations, and Special Warfare Training operations. The island is also used for ground and shore assault training exercises by the Marines. Fires caused by training exercises have resulted in large areas being burned over the last several years. The island has had long history of habitat destruction by the introduction of feral animals. Goats, pigs and deer have been removed from the island and the Navy is considering plans for habitat restoration. The Navy is currently developing an Environmental Impact Statement for new and expanded programs to support military training programs. The extent of the impact of these new programs on Island fox habitat is unknown at this time.

Table 4. Ownership of the islands inhabited by the Island fox.

Island		Ownership
NORTHERN ISLANDS		
San Miguel	(*U. l. littoralis*)	U.S. Park Service
Santa Rosa	(*U. l. santarosae*)	U.S. Park Service
Santa Cruz	(*U. l. santacruzae*)	U.S. Park Service / The Nature Conservancy
SOUTHERN ISLANDS		
San Nicolas	(*U. l. dickeyi*)	U.S. Navy
Santa Catalina	(*U. l. catalinae*)	Santa Catalina Island Conservancy (87%), Private (13%)
San Clemente	(*U. l. clementae*)	U.S. Navy

INADEQUACY OF EXISTING REGULATORY MECHANISMS

State Laws and Regulations. The island fox, as a species, is listed as a "threatened" by the State of California. Commercial and recreational hunting and trapping is prohibited. No state recovery plan exists. State listing has not prevented the fox's decline and does not allow regulation of private and federal land use. The State of California has not provided significant funding to recover declining populations.

Development on Santa Catalina Island is regulated by Los Angeles County and the California Coastal Commission.

Federal Laws and Regulations.
While the National Park Service has recently participated in emergency actions to stave off extinction of critical fox populations, it does not have an Island fox management or recovery plan.

The U.S. Navy supported Island fox monitoring on San Nicolas Island from 1980 through 1984, and intermittently until the early 1990's. On San Clemente Island, the Navy has either supported or granted permission for monitoring activities from 1988 through 1999.

Private Conservation Activities.
The Santa Catalina Conservancy has funded recent investigations to determine the cause and degree of the decline of the fox population on Santa Catalina Island.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Island foxes are not a hunted or used for other commercial, recreational or educational purposes. Other than animals found dead, island foxes are not collected for museum display, or for experimental purposes.

DISEASE OR PREDATION

Predation. The level of golden eagle predation on island foxes is undoubtedly significantly higher than during historic or prehistoric levels, especially on the northern Channel Islands. Prior to 1999, golden eagles were never known to nest on the Channel Islands (P. Collins, Santa Barbara Museum of Natural History, personal communication). While golden eagles were recorded as visitors to the northern Channel Islands, they were ephemeral in their occurrence and we never found in large numbers. Starting in the mid- to late-1990s, observations of golden eagles on Santa Cruz Island increased and a recently active nest was found on the island in 1999. Based on ground and helicopter surveys conducted in 1999, golden eagle numbers were estimated at 7-15 individuals on the northern Channel Islands, with the possibility of four nesting pairs on Santa Cruz Island (T. Coonan, G. Roemer, B. Latta, personal communication). The recent increase in their numbers and their establishment as a resident breeder may be due to a prey base of feral pigs (*Sus scrofa*) and sheep that were not historically present. In addition, golden eagles may have been discouraged from breeding on the islands by bald eagles (*Haliaeetus leucocephalus*), which bred historically on the northern Channel Islands but which have not successfully nested there since the 1940's (Kiff 1980). Moreover, on San Miguel and Santa Rosa Islands, historic sheep and cattle grazing has changed the island's vegetation from shrub communities to non-native grasslands (Hochberg *et al*. 1979), which offer much less cover from aerial predators. An examination of fox carcasses found on Santa Cruz and San Miguel Islands (see above) indicate predation by golden eagles, and strongly suggest that the eagles are largely responsible for the decline observed in the fox populations observed on the Northern Channel Islands.

A bald eagle reintroduction program began in 1980 on Santa Catalina Island. Bald eagles currently nest on the island, but the population is maintained by human manipulation of eggs and nestlings. Unaided nesting is thus far unsuccessful due to DDE contamination. While bald eagles are of similar size to golden eagles, there are no records of Island foxes in the diet of bald eagles on the island. Bald eagles are primarily piscivorus, and mammal prey is more commonly taken in the form of carrion.

Red-tailed hawks (*Buteo jamaicensis*) have been observed feeding on the carcasses of island fox pups. However, as the hawks have occupied the Channel Islands simultaneously with the island fox for many generations, it is unlikely that they have contributed significantly to the recent decline observed in the fox populations.

Domestic dogs are found on Santa Catalina Island and are known to kill island foxes. Because Island foxes have evolved without any natural terrestrial predators, they are behaviorally ill-equipped to handle

interactions with domestic dogs. While the Catalina Conservancy has a leash law for dogs that are brought into the interior of the island, it is not adequately enforced.

Disease. The threat of disease is very serious for Island foxes due to their small population sizes and restricted ranges. Previous work by Garcelon *et al.* (1992) and Roemer *et al.* (1999) demonstrate that Island foxes have been exposed to a variety of canine disease agents. Antibodies to canine distemper we not found in any of the Island fox populations. Gray foxes are highly susceptible to canine distemper (Hoff *et al.* 1974, Nicholson and Hill 1984), and can even contract the disease if given the distemper vaccine used for domestic dogs (Halbrooks *et al.* 1981). The potential consequences of introduction of a disease outbreak has recently been made evident on Santa Catalina Island, where the population has undergone a catastrophic decline attributed to canine distemper (see above). Rabies is another serious threat to Island foxes, as it is so lethal that few individuals survive to develop immunity.

Contact with domestic dogs is the most likely mechanism for the transfer of disease to Island fox populations. Although National Park Service and U.S. Navy regulations do not allow domestic dogs on their islands, boaters have been observed bringing dogs ashore on San Miguel and San Clemente Islands. Dogs have also been ashore at Santa Cruz Island (G. Roemer, Institute for Wildlife Studies, personal communication). On Santa Catalina Island, residents and visitors are allowed to brings dogs to the island. Even a single dog shedding a virus from a highly contagious disease such as rabies, distemper, or parvovirus could cause a serious population decline in an Island fox population. In the case of parvovirus and distemper, the dog does not even need to have direct contact with a fox in order to transmit the disease agent.

Antigen for canine heartworm was found in four of the six Island fox populations (Roemer *et al.*, in press). Overall seroprevalence was 72% from samples collected in 1988, and 78% for samples collected in 1997-98, which is significantly higher than levels reported for the mainland Gray fox (0%-24%). Although heartworm can have a debilitating effect on the health of wild canids (Weinman and Garcia 1980, Carlson and Nielsen 1983), it has likely been present for at least a decade and probably has not played an important role in the recent decline of foxes on the northern Channel Islands (Roemer *et al.*, in press). The extent of heartworm disease in the Island fox populations is unknown at this time.

OTHER NATURAL OR ANTHROPOGENIC FACTORS

On three islands where human populations and paved roads are present, Island foxes are susceptible to mortality associated with vehicle collisions. On San Nicolas Island the Navy reports that approximately 40 foxes a year are killed by vehicle collisions (G. Smith, personal communication). While no annual data on foxes killed on roads is available for San Clemente Island, it is believed to be a major source of fox mortality on that island (Garcelon 1999). Several foxes have been reported hit by vehicles on Santa Catalina Island in recent years (D. Garcelon, pers. obs.). Due to the small body size of the Island fox, and the dense vegetation along road sides, it is likely that most deaths of foxes due to collisions with vehicles go unobserved and unreported.

The long-term effects of the protection of the San Clemente loggerhead shrike on the Island fox on San Clemente Island are unknown at this time. As the shrike is a federally listed species, and there have been two instances were foxes have preyed on shrike nestlings, intensive management of the Island fox has been undertaken in recent years, including lethal control. The recent alternative to lethal control has been holding foxes in captivity until shrikes are less vulnerable to terrestrial predators. While this alternative has less impact on the adult survival, it likely impacts reproduction and the survival of dependent offspring.

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