Occurrence in captivity

As of September 2002, there are approximately 175 red wolves in captivity at 33 facilities throughout the United States and Canada (USFWS unpubl.). The purpose of the captive population is to safeguard the genetic integrity of the species and to provide animals for reintroduction. In addition, there are propagation projects on two small islands off the South Atlantic and Gulf Coasts of the U.S. which, through reintroduction of known breeding individuals and capture of their offspring, provide wild-born pups for release into mainland reintroduction projects (USFWS 1990).

Current or planned research projects

In an effort to understand and manage red wolf hybridisation with coyotes and red wolf x coyote hybrids, the USFWS is implementing a Red Wolf Adaptive Management Plan (RWAMP) (Kelly 2000). The plan, which employs an aggressive science-based approach to determine if hybridisation can be managed, was developed after consultation with numerous wolf biologists and geneticists and first implemented in 1999 (Kelly *et al.* 1999; Kelly 2000). The goal of the plan is to assess whether hybridisation can be managed such that it is reduced to an acceptably low level (see Conservation status: Threats above). As of September 2002, the initial results from the RWAMP indicate that this seems to be the case. If these initial results hold, the next questions that need to be addressed for the conservation of the red wolf in the wild will be: (1) what is the long-term feasibility of sustaining the intensive management of the RWAMP?; and (2) will introgression rates remain at an acceptable level in the absence of the current intensive management? As part of the RWAMP, several research projects are underway:

L. Waits and J. Adams (University of Idaho, USA) are using non-invasive genetic techniques to monitor presence and distribution of canids in the reintroduction area, and are working to improve genetic identification techniques.

The USFWS is examining whether red wolves and coyotes compete with each other for space or share space and partition resources, and is testing the use of captive-reared pups fostered into the wild red wolf population to enhance genetic diversity.

P. Hedrick and R. Frederickson (Arizona State University, USA) are conducting sensitivity analyses of a deterministic genetic introgression model.

D. Murray (Trent University, Canada) is developing a survival-based spatial model of wolf-coyote interactions.

M. Stoskopf and K. Beck (North Carolina State University, USA) are studying the use of GPS collars to monitor wolf movements, the social behaviour of red wolves and coyotes, and the epidemiology of coyote introgression into the wild red wolf population.

K. Goodrowe (Point Defiance Zoo and Aquarium, Washington, USA) is conducting extensive research regarding various aspects of the red wolf reproductive cycle.

D. Rabon (University of Guelph, Canada) is studying the roles of olfactory cues and behaviour in red wolf reproduction.

Core literature

Kelly 2000; Kelly *et al*. 1999; Nowak 1979, 2002; Paradiso and Nowak 1972; Phillips. *et al*. 1995, 2003; Riley and McBride 1972; USFWS 1990.

Reviewers: David Mech, Richard Reading, Buddy Fazio.
Editors: Claudio Sillero-Zubiri, Deborah Randall, Michael Hoffmann.

4.3 Gray fox
Urocyon cinereoargenteus
(Schreber, 1775)
Least Concern (2004)

T.K. Fuller and B.L. Cypher

Other names

English: tree fox; **Spanish:** zorro, zorro gris, zorra gris (Mexico), zorro plateado, gato de monte (southern Mexico), gato cervan (Honduras).

Taxonomy

Canis cinereoargenteus Schreber, 1775. Die Säugethiere, 2(13):pl. 92[1775]; text: 3(21):361[1776]. Type locality: "eastern North America" ("Sein Vaterland ist Carolina und die Wärmeren Gegenden von Nordamerica, vielleicht auch Surinam").

Gray foxes traditionally were considered to be distinct from other foxes. Clutton-Brock *et al*. (1976) and Van Gelder (1978) proposed reclassifying gray foxes as *Vulpes*. However, Geffen *et al*. (1992e) determined that gray foxes represent an evolutionary lineage that is sufficiently distinct from vulpine foxes to warrant recognition as a separate genus.

A molecular phylogenetic analysis of the Canidae showed that there are four monophyletic clades (*Canis* group, *Vulpes* group, South American foxes and the bush dog/maned wolf clade) and three distantly related basal taxa, one of which is the gray fox (*U. cinereoargenteus*; Wayne *et al*. 1997). The gray fox often clusters with two other ancient lineages, the raccoon dog (*Nyctereutes procyonoides*) and the bat-eared fox (*Otocyon megalotis*) but the exact relationship among these taxa is unclear. The early origination of these lineages has resulted in significant sequence divergence that may have masked unique sequence similarities (i.e., synapomorphies) that would have resulted from common ancestry (Wayne *et al*. 1997). Despite the unclear affinities, *Urocyon* is currently considered a basal genus within the Canidae and has only two surviving members, the gray and island fox (*Urocyon littoralis*).

Chromosome number is 2n=66 (Fritzell and Haroldson 1982).

Description

The gray fox is medium sized with a stocky body, moderately short legs and medium-sized ears (Table 4.3.1). The coat is grizzled grey on the back and sides with a dark longitudinal stripe on top of a black-tipped tail, dark and white markings on its face, and a conspicuous cinnamon-rusty colour on its neck, sides and limbs. There is also white on its ears, throat, chest, belly and hind limbs, while the undercoat is mostly buff and grey. The tail is thick and bushy, and the fur is coarse-appearing. The dental formula is 3/3-1/1-4/4-2/3=42. The posterior ventral border of the dentary has a prominent notch or "step", and on the cranium, the temporal ridges are separated anteriorly but connect posteriorly to form a distinctive "U" shape (Hall 1981).

Table 4.3.1 Body measurements for the gray fox from California, USA (Grinnell *et al*. 1937).

Total length male	981mm (900–1,100) n=24
Total length female	924mm (825–982) n=20
T male	385mm (333–443) n=24
T female	357mm (280–407) n=20
HF male	137mm (100–150) n=24
HF female	130mm (115–140) n=20
E male	79mm (60–89) n=24
E female	77mm (55–101) n=20
WT male	4.0kg (3.4–5.5) n=18
WT female	3.3kg (2.0–3.9) n=16

Adult gray fox, sex unknown. Fresno, California, USA, 2003.

Karen Brown

Subspecies Up to 16 subspecies are recognised (Fritzell and Haroldson 1982):
- — *U. c. borealis* (New England)
- — *U. c. californicus* (southern California)
- — *U. c. cinereoargenteus* (eastern United States)
- — *U. c. costaricensis* (Costa Rica)
- — *U. c. floridanus* (Gulf states)
- — *U. c. fraterculus* (Yucatan)
- — *U. c. furvus* (Panama)
- — *U. c. guatemalae* (southernmost Mexico south to Nicaragua)
- — *U. c. madrensis* (southern Sonora, south-west Chihuahua, and north-west Durango)
- — *U. c. nigrirostris* (south-west Mexico)
- — *U. c. ocythous* (Central Plains states)
- — *U. c. orinomus* (southern Mexico, Isthmus of Tehuantepec)
- — *U. c. peninsularis* (Baja California)
- — *U. c. scottii* (south-western United States and northern Mexico)
- — *U. c. townsendi* (California and Oregon)
- — *U. c. venezuelae* (Colombia and Venezuela)

Similar species Island fox (*Urocyon littoralis*): very similar in appearance to the gray fox, but tends to be somewhat darker and is 25–50% smaller (Crooks 1994; Moore and Collins 1995); confined to the Channel Islands off the southern coast of California, and considered to be descended from mainland gray foxes (Collins 1982; Wayne *et al*. 1991; Moore and Collins 1995).

Current distribution

The gray fox is widespread in forest, woodland, brushland, shrubland, and rocky habitats in temperate and tropical regions of North America, and in northernmost montane regions of South America.

Historical distribution In North America, the historical northernmost distribution of the gray fox probably was somewhat further south than its current northern limit (Fritzell and Haroldson 1982). Also, the range of the species probably did not extend significantly into the Great Plains because of the lack of brushy cover. Habitat modifications, such as fire suppression and tree planting, have facilitated occupation of this biome (Fritzell 1987). The species also was formerly found on Martha's Vineyard, a small offshore island in the state of Massachusetts (Waters 1964). In Central America, gray foxes were much more widespread before the conversion of forested land into pastures and urban areas (de la Rosa and Nocke 2000).

Current distribution The gray fox ranges from the southern edge of central and eastern Canada, and Oregon, Nevada, Utah, and Colorado in the United States south to

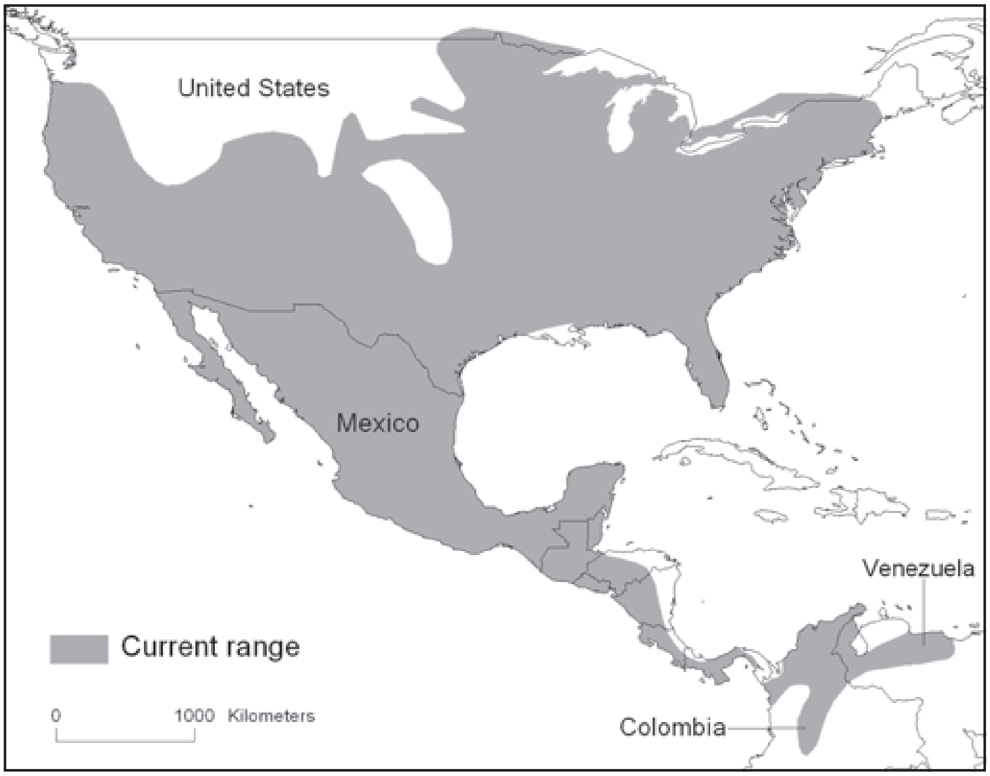

Figure 4.3.1. Current distribution of the gray fox.

northern Venezuela and Colombia; and from the Pacific coast of the United States to the Atlantic and Caribbean oceans. The species is not found in the northern Rocky Mountains of the United States, or in the Caribbean watersheds of Honduras, Nicaragua, Costa Rica, and western Panama (Figure 4.3.1).

Range countries Belize, Canada, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, United States of America, Venezuela (Hall 1981; Fritzell 1987; Eisenberg 1989; de la Rosa and Nocke 2000).

Relative abundance

The gray fox is common in occupied habitat, but appears to be restricted to locally dense habitats where it is not excluded by sympatric coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) (Farias 2000b).

Estimated populations/relative abundance and population trends No estimates of total gray fox abundance have been attempted. Reported densities range from 0.4/km² in California (Grinnell *et al*. 1937) to 1.5/km² in Florida (Lord 1961). There is no good evidence that gray fox numbers are increasing or decreasing in any part of their range.

Habitat

In eastern North America, the gray fox is most closely associated with deciduous/southern pine forests interspersed with some old fields and scrubby woodlands (Hall 1981). In western North America, it is commonly found in mixed agricultural/woodland/chaparral/riparian landscapes, and shrub habitats. The species occupies forested areas and thick brush habitats in Central America, and forested montane habitats in South America (Eisenberg 1989). Gray foxes occur in semi-arid areas of the south-western U.S. and northern Mexico where cover is sufficient. They appear to do well on the margins of some urban areas (Harrison 1997).

Food and foraging behaviour

Food Gray foxes have been identified as the most omnivorous of all North American fox species (Fritzell and Haroldson 1982). They consume primarily rabbits (*Sylvilagus* spp.) and rodents during cold winter months, then greatly diversify their diets in spring and summer to include insects, particularly Orthoptera (e.g., grasshoppers), birds, natural fruits and nuts, and sometimes carrion. Fruit and nut consumption often increases in the autumn as availability of these foods increases (Fritzell and Haroldson 1982).

Foraging behaviour Gray foxes are more active at night than during the day. They also increase their home ranges during late autumn and winter, possibly in response to changes in food resource availability and distribution. Male foxes also may increase their ranges during spring, probably in response to increased food requirements of more sedentary females and newborn pups (Follman 1973;

Nicholson *et al*. 1985). No information has been reported on specific hunting behaviour of gray foxes.

Damage to livestock or game Although historically considered a potentially significant predator of small game and poultry, gray foxes currently are not considered an important threat to game populations or livestock (Fritzell and Haroldson 1982).

Adaptations

With relatively short legs, a greater ability to rotate the radius on the ulna compared to other canids, and a relatively greater ability to abduct the hind limb, gray foxes are notable tree climbers (Feeney 1999). They can climb branchless, vertical trunks to heights of 18m, as well as jump vertically from branch to branch.

Social behaviour

Monogamy with occasional polygyny is probably most typical in gray foxes (Trapp and Hallberg 1975), but few quantitative data are available, and it is not known if breeding pairs remain together during consecutive years. The basic social unit is the mated pair and their offspring of the year (Trapp and Hallberg 1975; Greenberg and Pelton 1994). Offspring typically disperse at 9–10 months of age, and although long distance dispersal (over 80km) has been reported (Sheldon 1953; Sullivan 1956), young foxes may also return to and settle down near their natal ranges (Nicholson *et al*. 1985). Gray foxes exhibit some territoriality, as home ranges of adjacent family groups may overlap, but core areas appear to be used exclusively by a single family (Chamberlain and Leopold 2000). Home range size ranges from 0.8km^2 (Yearsley and Samuel 1982) to 27.6km^2 (Nicholson 1982), and size may vary with habitat quality and food availability.

Gray foxes scent mark by depositing urine and faeces in conspicuous locations (Fritzell and Haroldson 1982). They also communicate vocally via growls, alarm barks, screams, and "coos" and "mewing" sounds during greetings (Cohen and Fox 1976). Gray foxes engage in allogrooming with adults grooming juveniles and each other (Fox 1970).

Reproduction and denning behaviour

Gray foxes reach sexual maturity at 10 months of age, although not all females breed in their first year (Wood 1958; Follman 1978). Breeding generally occurs from January to April with gestation lasting about 60 days (Sullivan 1956). Litter size ranges from 1–10 and averages around four pups (Fritzell 1987). Eyes of pups open at about 10–12 days. Pups accompany adults on foraging expeditions at three months and forage independently at four months (Trapp and Hallberg 1975). Females appear to be responsible to provision pups (Nicholson *et al*. 1985), although there is some evidence that males may also contribute to care of pups (Chamberlain 2002). Juveniles reach adult size and weight at about 210 days (Wood 1958).

During parturition and pup rearing, gray foxes use earthen dens, either dug themselves or modified from burrows of other species. They will also den in wood and brush piles, rock crevices, hollow logs, hollows under shrubs, and under abandoned buildings (Trapp and Hallberg 1975). Gray foxes may even den in hollows of trees up to nine metres above the ground (Davis 1960). In eastern deciduous forests, dens are in brushy or wooded areas where they are less conspicuous than dens of co-occurring red foxes (*Vulpes vulpes*) (Nicholson and Hill 1981). Den use diminishes greatly during non-reproductive seasons when gray foxes typically use dense vegetation for diurnal resting locations.

Competition

Red foxes are sympatric with gray foxes over much of the gray fox range, but competitive interactions between the two species are not well understood. Historically, differences in food and habitat preferences may have reduced competition between the species, but recent deforestation and other anthropogenic disturbances appear to have resulted in increased habitat use overlap (Churcher 1959; Godin 1977). Competition between gray and kit (*Vulpes macrotis*) or swift (*Vulpes velox*) foxes has not been recorded, probably because of differences in habitat preference (wooded and brushy versus shrub-steppe, arid and semi-arid desert and open grasslands, respectively) that precludes interactions between the species. Coyotes, on the other hand, opportunistically kill gray foxes (Wooding 1984; Farias 2000b; B. Cypher unpubl.), and appear to limit gray fox abundance in some areas (but see Neale and Sacks 2001). Gray fox abundance is inversely related to coyote abundance in California (Crooks and Soulé 1999), and gray fox numbers increased following coyote removal in Texas (Henke and Bryant 1999). In southern California, coyotes may limit gray foxes to thicker chaparral cover (Farias 2000b; Fedriani *et al*. 2000). Bobcats also may kill gray foxes (Farias 2000b). Conversely, gray fox populations may limit the number of weasels (*Mustela* spp.) in some areas (Latham 1952; Hensley and Fisher 1975).

Mortality and pathogens

Natural sources of mortality In addition to coyotes and bobcats, golden eagles (*Aquila chrysaetos*) and mountain lions (*Felis concolor*) kill gray foxes (Grinnell *et al*. 1937; Mollhagen *et al*. 1972).

Persecution In the past, gray foxes may have been persecuted because they were deemed predators of domestic livestock or poultry, or hunted as a result of general bounties, but persecution currently is not a significant mortality factor for the species.

Hunting and trapping for fur Trapping of gray foxes is legal throughout much of their range, and is likely to be the most important source of mortality where it occurs and probably can limit their populations locally. Annual harvests of gray foxes were approximately 182,000 in the 1970s and increased to 301,000 in the 1980s (Obbard *et al.* 1987). During 1994 to 1995, more than 80,000 gray foxes were harvested in 40 states (International Association of Fish and Wildlife Agencies unpubl.). In the south-eastern United States, gray foxes are traditionally hunted with hound dogs (Fritzell 1987). There is little evidence that regulated trapping has adversely affected gray fox population numbers.

Road kills Occasionally, gray foxes are hit by vehicles, but this does not appear to be a significant source of mortality. In Alabama, 14% of gray fox deaths were attributed to vehicles (Nicholson and Hill 1984).

Pathogens and parasites Local populations have been reduced as a result of distemper (Nicholson and Hill 1984) and rabies (Steelman *et al.* 2000). In Alabama, 36% of gray fox deaths were attributed to distemper (Nicholson and Hill 1984). Of 157 gray fox carcasses examined in the south-eastern United States, 78% were diagnosed with distemper (Davidson *et al.* 1992). A variety of external and internal parasites have been found among gray foxes including fleas, ticks, lice, chiggers, mites, trematodes, cestodes, nematodes, and acanthocephalans (Fritzell and Haroldson 1982). Gray foxes appear to be highly resistant to infestation by sarcoptic mange mites (Stone *et al.* 1972).

Longevity It is rare for a gray fox to live longer than 4–5 years, although Seton (1929) reported that some individuals could live 14–15 years.

Historical perspective

Humans have probably harvested gray foxes for their fur for as long as the two have been in contact with one another. Gray foxes are trapped for utilitarian and economic reasons (including the perceived elimination of livestock depredation), and also for recreation. However, recent changes in social attitudes towards trapping have resulted in lower participation in the activity and its outright ban in some states (e.g., Arizona, California, Colorado, Florida, Massachusetts, New Jersey) (Armstrong and Rossi 2000).

Conservation status

Threats No major threats, but habitat loss, fragmentation, and degradation, may be particularly problematic in regions where human numbers are increasing rapidly and important habitat is converted for agricultural, industrial, and urban uses.

Commercial use Because of its relatively lower fur quality compared to other species, commercial use of the gray fox is somewhat limited. However, 90,604 skins were taken in the United States during the 1991 and 1992 season (Linscombe 1994). In Mexico, gray foxes are frequently sold illegally as pets (R. List pers. comm.).

Occurrence in protected areas Gray foxes occur in numerous protected areas throughout their range, such as Big Bend NP, San Joaquin National Wildlife Refuge, Rocky Mountain NP and Everglades and Dry Tortugas NP, and Adirondack NP.

Protection status CITES – not listed.

Current legal protection The gray fox is legally protected as a harvested species in Canada and the United States (Fritzell 1987).

Conservation measures taken No specific measures are currently being implemented, and none appear necessary at this time.

Occurrence in captivity

According to ISIS, there are 74 foxes in captivity, although there may be more in the hands of private collections/ individuals who do not report to ISIS. Gray foxes appear to fare well in captivity and commonly are on display at zoos and wildlife farms.

Current or planned research projects

R. Sauvajot (U.S. National Park Service, Thousand Oaks, California) and collaborators at the Santa Monica Mountains National Recreation Area in California recently investigated gray fox ecology, space use, interspecific interactions, and response to human development.

Researchers at the Savannah River Ecology Laboratory (Aiken, South Carolina) are investigating the demographic characteristics of a non-harvested population of gray foxes in South Carolina.

R. List (Instituto de Ecologia, National University of Mexico) and colleagues are studying the ecology and demography of a closed gray fox population, in a 1.6km² reserve within central Mexico City, to determine management needs.

M. Gompper (University of Missouri, Columbia) has proposed a genetic and ecological investigation of an island gray fox population on Cozumel, Mexico.

Gaps in knowledge

Because of the relatively high abundance and low economic value of gray foxes, surprisingly little research has been conducted on this species. Basic ecological and demographic information is needed for each of the major habitats occupied by gray foxes. Also, data on the response of gray foxes to human-altered landscapes (e.g., urban environments) are needed. No region-wide or range-wide population estimate has been produced. Furthermore, extremely little is known about the status and ecology of gray foxes outside of the USA and Canada. The effects of gray foxes on populations of smaller vertebrates, especially in urban and suburban settings without larger predators, may be important.

Core literature

Fritzell 1987; Fritzell and Haroldson 1982; Hall 1981; Harrison 1997; Lord 1961; Trapp and Hallberg 1975.

Reviewers: Gary Roemer, Rurik List. **Editors:** Deborah Randall, Claudio Sillero-Zubiri, Michael Hoffmann.

4.4 Island fox
Urocyon littoralis (Baird, 1858)
Critically Endangered – CR:A2be+3e (2004)

G.W. Roemer, T.J. Coonan, L. Munson and R.K. Wayne

Other names

English: island gray fox, Channel Islands fox, California Channel Island fox.

Taxonomy

Vulpes littoralis Baird, 1858:143. Type locality: San Miguel Island, Santa Barbara County, California, USA [34°02'N, 120°22'W].

Urocyon is currently considered a basal genus within the Canidae and has only two surviving members, the gray fox (*U. cinereoargenteus*) and the island fox (*U. littoralis*) (Wayne *et al*. 1997). The island fox is believed to be a direct descendant of the gray fox, having reached the Channel Islands either by chance over-water dispersal or human-assisted dispersal (Collins 1991a, b). Each island population differs in genetic structure and of the five mtDNA haplotypes found in island foxes, none are shared with a nearby mainland sample of gray foxes. However, all island fox populations share a unique restriction enzyme site, clustering the populations into a single monophyletic clade (Wayne *et al*. 1991b). Population specific restriction-fragment profiles have been identified from minisatellite DNA (Gilbert *et al*. 1990), and multilocus genotypes from hypervariable microsatellite DNA were used to correctly classify 99% of 183 island/gray fox samples to their population of origin (Goldstein *et al*. 1999). The two mis-classifications occurred between nearby island populations. These data clearly justify the current classification of island foxes as a separate species (Wozencraft 1993) and the subspecific classifications of the six island populations (Hall 1981; Moore and Collins 1995).

Chromosome number is identical to *U. cinereoargenteus* with 2n=66; 62 acrocentric chromosomes, a submetacentric pair and two sex chromosomes (Wayne *et al*. 1991b).

Description

Island foxes are the smallest North American canid. Males are significantly heavier than females (Moore and Collins 1995) (Table 4.4.1). The head is grey with black patches on the lateral sides of the muzzle in the vicinity of the vibrissae, with black outlining the lips of both jaws. White patches

Table 4.4.1. Body measurements for the Island fox. Measures of adult foxes were taken in 1988 for all subspecies except for San Clemente (R. Wayne unpubl.). Weight for San Clemente foxes was measured in 1988 (D. Garcelon and G. Roemer unpubl.), other measures for San Clemente foxes are from Moore and Collins (1995).

	Northern Channel Islands	Southern Channel Islands
HB male	536mm (470–585) n=44	548mm (513–590) n=28
HB female	528mm (456–578) n=50	538mm (475–634) n=30
T male	213mm (145–255) n=44	272mm (230–310) n=51
T female	202mm (115–265) n=50	248mm (180–295) n=46
HF male	111mm (94–124) n=44	112mm (104–120) n=51
HF female	107mm (95–122) n=50	107mm (92–115) n=46
E male	60mm (53–68) n=44	63mm (55–72) n=51
E female	60mm (54–67) n=50	62mm (59–67) n=46
WT male	2.0kg (1.4–2.5) n=44	2.0kg (1.4–2.5) n=51
WT female	1.8kg (1.5–2.3) n=50	1.8kg (1.3–2.4) n=46

Adult female island fox, San Miguel Island, California, USA, 1994.

Timothy J. Coonan