Europe and North and Central Asia (Palearctic)

5.1 Arctic fox
Alopex lagopus (Linnaeus, 1758)
Least Concern (2004)

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Other names

English: polar fox; **Finnish:** naali; **French:** renard polaire, isatis; **German:** polarfuchs; **Icelandic:** tófa; **Russian:** Песец; **Swedish:** fjällräv; **Indigenous names:** Saami: njálla, svála (Norway, Sweden, Finland, Russia).

Taxonomy

Canis lagopus Linnaeus, 1758. Syst. Nat., 10th ed., 1: 40. Type locality: "alpibus Lapponicis, Sibiria," restricted to "Sweden (Lapland)".

The Arctic fox is sometimes placed in a subgenus of *Vulpes* and sometimes in *Canis*. However, the species is still most often placed in *Alopex* (e.g., Corbet and Hill 1991). The most closely related species are swift fox (*Vulpes velox*) and kit fox (*V. macrotis*), neither of which occurs in the tundra. Viable hybrids between Arctic fox and red fox (*Vulpes vulpes*) are routinely produced by artificial insemination in fur farms, but both sexes appear to be infertile (Nes *et al.* 1988). Only one case of such hybridisation has been recorded in the wild, the progeny of a silver fox vixen that had escaped from captivity in Iceland and a native Arctic fox male (Gudmundsson 1945).

Variable chromosome numbers of 2n=48–50, due to Robertsonian translocation (Mäkinen 1985), and 2n=52 (Wipf and Shackelford 1949) have been recorded. Relative frequencies of karyotypes in nature are not known but in Finnish fur farms, foxes with the 2n=49 chromosome constitution are less fertile than females with 2n=48 or 2n=50. Furthermore, in these foxes the segregation of the karyotypes within litters of biparental 2n=49 matings is in favour of the 2n=48 karyotype such that its frequency may be increasing in captivity (Mäkinen 1985).

Description

The Arctic fox is a small fox with rather short legs and a long fluffy tail (Table 5.1.1). Males are slightly larger than females. The Arctic fox has very thick and soft winter fur with dense underfur and long guard hairs. The species occurs in two distinct colour morphs, "blue" and "white". Each morph also changes seasonally: "blue" moults from chocolate brown in summer to lighter brown tinged with blue sheen in winter. In winter, the "white" morph is almost pure white with a few dark hairs at the tip of the tail

and along the spine, while in summer, it is brown dorsally and light grey to white on its underside. Colour morphs are determined genetically at a single locus, "white" being recessive (Adalsteinsson *et al.* 1987). The "blue" morph comprises less than 1% of the population throughout most of its continental range, but comprises 25–30% in Fennoscandia (Norway, Sweden and Finland) and 65–70% in Iceland (Adalsteinsson *et al.* 1987). The proportion of blue morphs also increases in coastal areas and on islands, where it can reach up to 100% (e.g., Mednyi Island, Russia; St. Paul Island, Alaska). Within each morph, there is considerable variation in appearance, which seems to be independent of the locus for colour morph (Hersteinsson 1984). In Sweden, there occasionally are sand-coloured foxes in summer, but they appear to be of the white morph without brown pigment, while in

Table 5.1.1 Body measurements for the Arctic fox in Iceland (P. Hersteinsson unpubl.).

HB male	578mm ± 31 n=89
HB female	548mm ± 33 n=85
T male	271mm ± 20 n=65
T female	262mm ± 23 n=55
WT male	June–July: 3.58kg ± 0.45 n=478
	November–February: 4.23kg ± 0.60 n=338
WT female	June–July: 3.14kg ± 0.38 n=514
	November–February: 3.69kg ± 0.55 n=245

Adult male Arctic fox. Härjedalen, Sweden, 2000.

Magnus Tannerfeldt

Iceland, cinnamon coloured foxes of both the white and blue colour morph occur (Adalsteinsson *et al.* 1987, unpubl.). The dental formula is 3/3-1/1-4/4-2/3=42.

Subspecies Audet *et al.* (2002) recognise eight subspecies, but we list only four:
— *A. l. lagopus* (most of the range).
— *A. l. semenovi* (Mednyi Island, Commander Islands, Russia).
— *A. l. beringensis* (Bering Island, Commander Islands, Russia).
— *A.l. pribilofensis* (Pribilof Islands, Alaska).

Similar species The Arctic fox cannot be mistaken for any other tundra-living animal. The red fox (*Vulpes vulpes*), which is the only other small canid in tundra areas, is larger, with relatively longer tail and ears, as well as a slightly longer and narrower muzzle and distinctly red fur, although the black (silver) and cross phenotypes are common in the far north.

Distribution
Current distribution The Arctic fox has a circumpolar distribution in all Arctic tundra habitats. It breeds north of and above the tree line on the Arctic tundra in North America and Eurasia and on the alpine tundra in Fennoscandia, ranging from northern Greenland at 88°N to the southern tip of Hudson Bay, Canada, 53°N. The southern edge of the species' distribution range may have moved somewhat north during the 20th century resulting in a smaller total range (Hersteinsson and Macdonald 1992). The species inhabits most Arctic islands but only some islands in the Bering Strait.

The Arctic fox was also introduced to previously isolated islands in the Aleutian chain at the end of the 19th century by fur industry (Bailey 1992). It has also been observed on the sea ice up to the North Pole.

Historical distribution During the last glaciation, the Arctic fox had a distribution along the ice edge, and Arctic fox remains have been found in a number of Pleistocene deposits over most of Europe and large parts of Siberia (Chesemore 1975).

Range countries Canada, Denmark (Greenland), Finland, Iceland, Norway, Russia, Sweden, USA (Alaska) (Hall and Kelson 1959; Vibe 1967; Nasimovic and Isakov 1985; Mitchell-Jones *et al.* 1999).
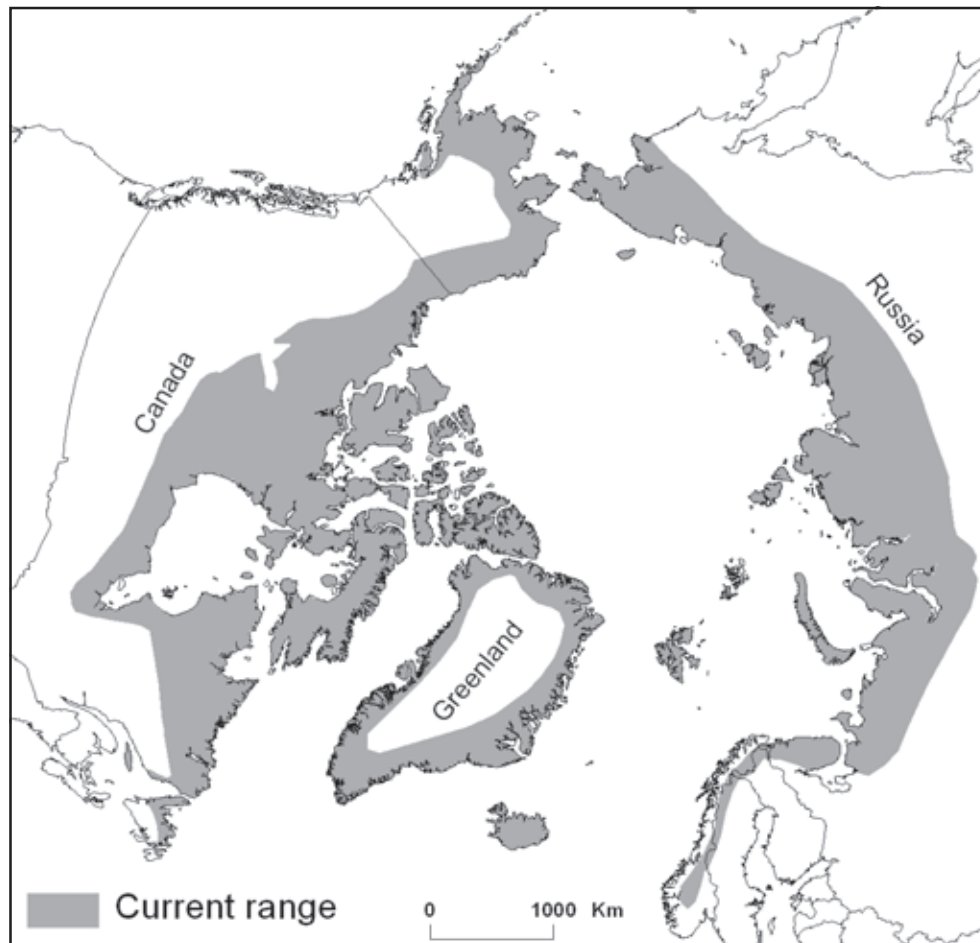

Figure 5.1.1. Current distribution of the Arctic fox.

Current range

0   1000 Km

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Relative abundance

The world population of Arctic foxes is in the order of several hundred thousand animals (Table 5.1.2). Most populations fluctuate widely in numbers between years in response to varying lemming numbers. Only a few populations have been studied directly, so the following population figures must be treated with caution. In most areas, however, population status is believed to be good. The species is common in the tundra areas of Russia, Canada, coastal Alaska, Greenland and Iceland. Exceptions are Fennoscandia, Mednyi Island (Russia) and Pribilof Islands, where populations are at critically low levels. On the Pribilof Islands, fox populations are now low and appear to be declining further. Vagrant Arctic foxes are common over the northern sea-ice where they follow polar bears as scavengers.

Table 5.1.2. The status of Arctic fox in various range countries (Population: C=common, R=rare; Trend: S=stable, I= increasing, D= declining).

Country (area)	Population/ abundance	Approx number	Trend
Canada	C	100,000 ?	S ?
USA (coastal Alaska)	C	10,000 ?	S ?
Greenland	C	> 10,000 ?	S ?
Russia (mainland)	C	2–800,000 ?	S/I ?
Russia (Mednyi Island)	R	100	?
Russia (Bering Island)	C	800–1,000	S
Iceland	C	> 6,000	I
Finland	R	20	D
Norway (mainland)	R	50	D
Norway (Svalbard)	C	2–3000	S
Sweden	R	50	D

Estimated populations/relative abundance and population trends The density of occupied natal Arctic fox dens varies from 1–3/100km² in the whole tundra zone of Siberia and North America (Boitzov 1937; Macpherson 1969), to about 4/100km² in coastal Alaska, Svalbard and Fennoscandia (Eberhardt *et al.* 1982; Prestrud 1992c; Dalerum *et al.* 2002), 7/100km² on Herschel Island, Yukon (Smits and Slough 1993) and up to 8/100km² in protected areas in Iceland (Hersteinsson *et al.* 2000).

In North America, there are no published population estimates for Canada or the USA. If North America's fur harvest until the 1980s is compared with production figures from Russia, the total Canadian Arctic fox population should be in the order of 100,000 animals and the Alaskan population around 10,000 individuals. Historically numbering thousands of individuals, Pribilof fox populations have declined to only a few hundred (White 1992).

The total Russian population size is unknown but could be in the order of 200,000–800,000 animals; Nasimovic and Isakov (1985) reported the number of live animals on the Taymyr Peninsula alone to be 52,000 during a low period and up to 433,000 animals in a peak year (1970 to 1971). A decline during the 1960s to 1980s was reported from many Siberian areas (Nasimovic and Isakov 1985), but lower fur prices and a breakdown of the Soviet trading system have probably relieved the pressure on the species. The endangered population of the subspecies *A. l. semenovi* on Mednyi Island comprises around 100 animals (Goltsman *et al.* 1996). The population on the neighbouring Bering Island (*A. l. beringensis*) is reported as stable at around 800–1,000 animals; the same review reports the Kola Peninsula population to number 1,000–2,000 animals (Potansky 1993). However, adjacent areas in Finland harbour less than 20 Arctic foxes, so this figure appears to be an overestimate.

In Fennoscandia, the population decreased dramatically due to over-harvest at the beginning of the 20th century. Local populations have been driven to near extinction by hunting; for example, on mainland Fennoscandia. Furthermore, the situation deteriorated during the 1980s and 1990s because of an absence of lemming peaks. Recent population estimates total 120 adults, around 50 of which are found in Sweden (Angerbjörn *et al.* 1995; Löfgren and Angerbjörn 1998), 50 in Norway (Frafjord and Rofstad 1998), and less than 20 in Finland (Kaikusalo *et al.* 2000). On the island Svalbard (Norway), the Arctic fox is common, with a population density of 1–1.5 animals per 10km² and an approximate total autumn population of 2,000–3,000 individuals (P. Prestrud pers. comm.). In Iceland, the population has gone through long-term population fluctuations with a low in the 1970s of around 1,300 individuals in autumn to a high of over 6,000 individuals in 1999 and apparently still increasing (Hersteinsson 2001). Little information is available on fox population density in Greenland, but it is common in coastal areas.

Habitat

Arctic and alpine tundra on the continents of Eurasia, North America and the Canadian archipelago, Siberian islands, Greenland, inland Iceland and Svalbard. Subarctic maritime habitat in the Aleutian island chain, Bering Sea Islands, Commander Islands and coastal Iceland.

Food and foraging behaviour

Food The Arctic fox is an opportunistic predator and scavenger but in most inland areas, the species is heavily dependent on fluctuating rodent populations. The species' main prey items include lemmings, both *Lemmus* spp. and *Dicrostonyx* spp. (Macpherson 1969; Angerbjörn *et al.* 1999). In Fennoscandia, *Lemmus lemmus* was the main prey in summer (85% frequency of occurrence in faeces) followed by birds (Passeriformes, Galliformes and Caridriiformes, 34%) and reindeer (*Rangifer tarandus*) (21%; Elmhagen *et al.* 2000). In winter, ptarmigan and

grouse (*Lagopus* spp.) are common prey in addition to rodents and reindeer (Kaikusalo and Angerbjörn 1995). Changes in fox populations have been observed to follow those of their main prey in three- to five-year cycles (Macpherson 1969; Angerbjörn *et al*. 1999).

Foxes living near ice-free coasts have access to both inland prey and sea birds, seal carcasses, fish and invertebrates connected to the marine environment, leading to relatively stable food availability and a more generalist strategy (Hersteinsson and Macdonald 1996). In late winter and summer, foxes found in coastal Iceland feed on seabirds (*Uria aalge, U. lomvia*), seal carcasses and marine invertebrates. Inland foxes rely more on ptarmigan in winter, and migrant birds, such as geese and waders, in summer (Hersteinsson and Macdonald 1996). In certain areas, foxes rely on colonies of Arctic geese, which can dominate their diet locally (Samelius and Lee 1998).

Foraging behaviour Arctic foxes forage singly, presumably the most efficient foraging technique in view of the species' main prey base of rodents and birds. When food is abundant, Arctic fox cache food for later use. Caches can be either of single prey items or large items, with varying contents that may include lemmings or goose eggs (Chesemore 1975).

Damage to livestock and game In Iceland, lamb carcasses frequently are found among prey remains at dens resulting in the species being considered a pest. Although individual foxes may indeed prey on lambs, it is more likely that a large proportion of the lambs have been scavenged (Hersteinsson 1996). Arctic foxes are known to prey on wildfowl (Sovada *et al*. 2001a) and occasionally kill reindeer calves (Prestrud 1992a).

Adaptations

The Arctic fox has many physical adaptations to the Arctic environment. Arctic fox fur has the best insulative properties among all mammals, and individuals do not, under any naturally occurring temperatures, need to increase metabolic rate to maintain homoeothermy (Prestrud 1991). Arctic foxes change between summer and winter pelage, thereby adjusting their insulating capabilities and enhancing their camouflaging potential. Arctic foxes further conserve body heat by having fur on the soles of their feet (Linnaeus thus named it *lagopus*, literally hare-foot), small ears, short noses, and the ability to reduce blood flow to peripheral regions of their bodies. In autumn, their weight may increase by more than 50% as fat is deposited for insulation and reserved energy (Prestrud 1991).

The species demonstrates a number of other physiological adaptations for energy conservation in winter. Resting metabolic rate, body-core temperature and food intake is lower in winter (Fuglei 2000). When travelling long distances, the Arctic fox falls into an energy-effective short gallop, similar to that of wolverines. Surprisingly, for Arctic foxes, the energetic cost of running is lower in winter than in summer, and is also lower during starvation than when feeding *ad lib* (Fuglei 2000).

Social behaviour

The basic social unit of the Arctic fox is the breeding pair. Both parents take an active part in rearing the cubs. For the first three weeks after birth, while the cubs are mostly dependent on milk, the female rarely leaves the den for any length of time and the male brings most of the food on which the female feeds during this energetically demanding period. As meat increasingly forms a larger constituent of the cubs' diet, the roles of the parents become more similar and the female takes an active part in hunting and provisioning the cubs. Non-breeding helpers, usually yearlings from the previous litter, may occur. Supernumerary females generally emigrate before pups attain independence of the den at 8–10 weeks (Hersteinsson and Macdonald 1982). However, on Mednyi Island, there are permanent Arctic fox groups comprising up to six adults (Frafjord and Kruchenkova 1995). Complicated social systems have also been observed on other islands (e.g., Iceland: Hersteinsson 1984; St Paul Island, Alaska: White 1992; Wrangel Island, Russia: Ovsyanikov 1993). Temporary groups of non-breeding individuals are also sometimes formed (Ovsyanikov 1993).

Arctic foxes normally are strongly territorial when breeding, with natal dens generally used by only one family group. Pairs may remain together in the same territory and use the same den for up to five years (Ovsyanikov 1993; A. Angerbjörn unpubl.). In some cases, individuals may maintain territories that include more than a single breeding pair. Furthermore, there are cases when breeding pairs have shared a den. However, this phenomenon seems to be restricted to close relatives (A. Angerbjörn and M. Tannerfeldt unpubl.).

Home ranges in inland areas vary with lemming abundance (15–36km²; Angerbjörn *et al*. 1997), but generally are smaller in coastal habitats (Iceland, 9–19km²: Hersteinsson and Macdonald 1982; Greenland, 10–14km²: Birks and Penford 1990; Alaska 5–21km²: Eberhardt *et al*. 1982) and vary widely on Svalbard (10–125km²; Frafjord and Prestrud 1992). Home ranges of group members generally overlap widely with each other, and very little with those of neighbouring groups. Combined group ranges contribute to territories from which occupants rarely stray (Hersteinsson and Macdonald 1982). Scent marking of territories with urine is common, while faeces appear to have little or no significance with regard to territory marking (Hersteinsson 1984). Vocalisations and postures aimed to attract the attention of conspecifics, such as an erect tail, are common during territory disputes (Hersteinsson 1984).

In Alaska, seasonal migrations are reported when individuals leave breeding grounds in autumn, travel to the coast, and return in late winter or early spring (Eberhardt *et al.* 1983). Large-scale emigrations have been recorded in Canada, Fennoscandia and Russia. These may result from drastic reductions in food supplies, such as a population crash in lemmings. The longest recorded movement was by a male who was recovered 2,300km from the point of tagging (Garrott and Eberhardt 1987).

Reproduction and denning behaviour

Mating occurs between February and May and births take place from April to July. Gestation lasts 51–54 days. Pup weight at birth is 80–85g in Iceland (P. Hersteinsson unpubl.) but may be less in areas with larger litter sizes. Captive foxes in Sweden had a birth weight of 73g for females and 77g for males (E. Derefeldt and A. Angerbjörn unpubl.). Litter size varies with food availability, being smaller in areas without rodents and larger in areas with rodents (Tannerfeldt and Angerbjörn 1998). Mean litter sizes at weaning were 2.4 on St. Paul Island (White 1992), 4.2 in Iceland (Hersteinsson 1993), 5.3 in Svalbard (Prestrud and Nilssen 1995), 6.7 in Canada (Macpherson 1969), 7.1 in Russia (Chirkova *et al.* 1959), and 6.3 in Fennoscandia (Tannerfeldt and Angerbjörn 1998). On Wrangel Island, in years with high lemming abundance, up to 19 pups per litter have been observed (Ovsyanikov 1993).

The ability of Arctic foxes to produce large litters is facilitated by their access to large and relatively safe dens. The primary function of breeding dens seems to be to provide shelter and protection against predators. Den sites are large with complex burrow systems, and the largest dens are preferred for breeding (Dalerum *et al.* 2002). These may have up to 150 entrances and are usually situated on elevated mounds, pingoes, tops of eskers, river banks or ridges, although dens located in bedrock and screes are more common in Svalbard (Prestrud 1992b) and Iceland (A. Angerbjörn pers. obs.). Good denning sites lie above the permafrost layer, accumulate comparatively little winter snow and are sun-exposed, often facing south. The average lifespan of dens in the Canadian tundra has been estimated at 330 years (Macpherson 1969). Some are used repeatedly, year after year, others infrequently.

Pup rearing is confined to the snow-free period from June to September, after which the young gradually become independent. Lactation generally lasts 8–10 weeks. In Sweden, growth rate from weaning in early July to late August was about 30g/day (C. Bergman and A. Angerbjörn unpubl.), and in Svalbard growth rate was 34g/day (Frafjord 1994). Foxes reach sexual maturity at 10 months.

Competition

The red fox is an especially dominant competitor and severe predator on juvenile Arctic foxes (Frafjord *et al.* 1989). The red fox is also known to have a similar diet and to take over Arctic fox breeding dens (Tannerfeldt *et al.* 2002). A northward spread of the red fox has been recorded in Canada (Hersteinsson and Macdonald 1992) and an increasing range above the tree-line in Scandinavia, where the red fox has the potential to restrict the range of the Arctic fox (Tannerfeldt *et al.* 2002). Other species feeding in the same small rodent guild are rough-legged buzzard (*Buteo lagopus*), snowy owl (*Nyctea scandiaca*) and skuas (*Stercorarius longicaudus*, *S. pomarinus*, *S. parasiticus*), but the degree of competition between these species is not known.

Mortality and pathogens

Natural sources of mortality The Arctic fox is a victim of predation, mainly from the red fox, wolverine (*Gulo gulo*) and golden eagle (*Aquila chrysaëtos*), while the brown bear (*Ursus arctos*) and wolf (*Canis lupus*) are also known to dig out dens. For Arctic foxes dependent on cyclic lemmings, starvation is an important cause of mortality during some years, particularly for juveniles (Garrott and Eberhardt 1982, Tannerfeldt *et al.* 1994). Cubs are known to eat their siblings, but there is no evidence of siblicide (ArvidSon and Angerbjörn 1996).

Persecution In Norway (Svalbard), Greenland, Canada, Russia, and Alaska, trapping is limited to licensed trappers operating in a specified trapping season. The enforcement of these laws appears to be uniformly good. In Iceland, a law was passed in 1957 stipulating that the state would pay two-thirds of all costs of an extermination campaign on the Arctic fox. The law was changed in 1994, but restricted government-sponsored hunting still continues over most of the country as the Arctic fox is considered a pest to sheep farmers and eider down collectors (Hersteinsson *et al.* 1989). On St Paul Island persecution has caused a dramatic decrease in population size in recent years (White pers. comm.).

Hunting and trapping for fur Hunting for fur has long been a major mortality factor for the Arctic fox. The total harvest for North America between 1919 and 1984 was approximately 40,000–85,000 annually (Garrott and Eberhardt 1987). Macpherson (1969) stated that the Canadian production was 10,000–68,000 pelts per year, and by the 1980s around 20,000 (Garrott and Eberhardt 1987). The yield from Alaska for the period 1925 to 1962 was from 3,900–17,000 pelts per year (Chesemore 1972). The Alaska harvest later decreased to 1,000–2,000 per year (Garrott and Eberhardt 1987).

The total fur returns from Siberia reached more than 100,000 animals in some years in the 1970s and 39–59% of the population could be killed each year (Nasimovic and Isakov 1985). These populations fluctuate widely and a large proportion of killed animals are young-of-the-year. A decline during the last few decades is apparent in many

Siberian areas (Nasimovic and Isakov 1985), but lower fur prices and a breakdown of the Soviet trading system have probably relieved the pressure on the species.

In Greenland, in the year 1800, the number of exported pelts per year was around 2,000. In 1939, the catch had increased to over 7,000 animals per year (Braestrup 1941). It later decreased to 2,000–5,000 pelts annually (Vibe 1967), and subsequently has decreased even further. See also Commercial use.

Road kills No assessment has been made, but it is probably very infrequent in tundra areas due to low traffic intensity. However, it is increasing in St. Paul Island due to increased vehicular traffic and in Iceland over the last two decades due to an increasing Arctic fox population and improved road system, leading to more traffic and higher motoring speeds (P. White unpubl., P. Hersteinsson unpubl.).

Pathogens and parasites The Arctic fox is a major victim and vector during outbreaks of Arctic rabies (Prestrud 1992c). In Iceland, encephalitozoonosis is suspected of playing a part in population dynamics (Hersteinsson *et al.* 1993). As a result of mange caused by the ear canker mite (*Otodectes cynotis*) introduced by dogs, the subspecies *A. l. semenovi* on Mednyi Island was reduced by some 85–90% in the 1970s to around 90 animals (Goltsman *et al.* 1996). The same parasite can be found in Icelandic Arctic foxes but apparently does not result in increased mortality there (Gunnarsson *et al.* 1991). In Iceland, the diversity and magnitude of intestinal parasite infestation was much higher among Arctic foxes in coastal than in inland habitats (Skírnisson *et al.* 1993). Kapel (1995) has reviewed the occurrence and prevalence of helminths in Arctic foxes in Greenland, North America and Siberia. In a study conducted in Sweden, Arctic fox cubs were found to have no serious parasitic infestations (Aguirre *et al.* 2000). *Trichinella* infestations of Arctic foxes seem to be largely associated with feeding from polar bear (*Ursus maritimus*) carcasses (Prestrud *et al.* 1993; Kapel 1995). There is a risk that domestic dogs transfer diseases to Pribilof Arctic foxes (White unpubl.).

Longevity The average lifespan for animals that reach adulthood is approximately three years. The oldest recorded individuals were 11 years of age (P. Hersteinsson unpubl.).

Historical perspective
The importance of the Arctic fox fur trade has a very long history. In Jordanes 'Getica' (Jordanes 551), Romans are described wearing dark-blue furs bought from the Suehans (Swedes), presumably traded from the "Screrefennae" (=Sami). The economy of the Inuits is closely tied to Arctic fox abundance (Chesemore 1972). Arctic fox skins were legal tender along with lamb skins and some other products in Iceland during the Middle Ages (Hersteinsson 1980). This may also have been so in other Nordic countries.

Conservation status
Threats Hunting for fur has long been a major mortality factor for the Arctic fox. With the decline of the fur hunting industry, the threat of over-exploitation is lowered for most Arctic fox populations (see Commercial use). In some areas gene swamping by farm-bred blue foxes may threaten native populations (see Occurrence in captivity). There can also be indirect threats such as diseases and organochlorine contaminants, or direct persecution (as on St. Paul Island for example). Misinformation as to the origin of Arctic foxes on the Pribilofs continues to foster negative attitudes and the long-term persistence of this endemic subspecies is in jeopardy.

Commercial use The Arctic fox remains the single most important terrestrial game species in the Arctic. Indigenous peoples have always utilised its exceptional fur; and with the advent of the fur industry, the Arctic fox quickly became an important source of income. Today, leg-hold traps and shooting are the main hunting methods. Because of their large reproductive capacity, Arctic foxes can maintain population levels under high hunting pressure. In some areas, up to 50% of the total population has been harvested on a sustainable basis (Nasimovic and Isakov 1985). However, this does not allow for hunting during population lows, as shown by the situation in Fennoscandia. The Arctic fox has nevertheless survived high fur prices better than most other Arctic mammals. Hunting has declined considerably in the last decades, as a result of low fur prices and alternative sources of income. In the Yukon, for example, the total value of all fur production decreased from $1.3 million in 1988 to less than $300,000 in 1994.

Occurrence in protected areas Good information is available only for Sweden and Finland. For Iceland, Arctic foxes could potentially appear in most protected areas.
— *Finland*: Malla, Käsivarren erämaa, Iiton palsasuot, Saanan luonnonsuojelualue, Muotkatunturin erämaa, Hanhijänkä Pierkivaaran jänkä, Pieran Marin jänkä, Kevo, Kaldoaivin erämaa, Paistunturin erämaa, Pulmankijärvi;
— *Sweden*: The National Parks Sarek, Padjelanta, and Stora Sjöfallet, in the county of Norrbotten; the Nature Reserves Vindelfjällen, Marsfjället, and Gitsfjället, in the county of Västerbotten; the Nature Reserves Hamrafjället, Henvålen–Aloppan, Vålådalen, Gråberget–Hotagsfjällen, Frostvikenfjällen, Sösjöfjällen and Skäckerfjällen, in the county of Jämtland.

Protection status CITES – not listed.
The Arctic fox is threatened with extinction in Sweden

(EN), Finland (CR) and mainland Norway (E). In 1983, following the introduction of mange due to ear canker mites (*Otodectes cynotis*) via dogs, the Mednyi Island foxes were listed in the Russian Red Data Book.

Current legal protection In most of its range, the Arctic fox is not protected. However, the species and its dens have had total legal protection in Sweden since 1928, in Norway since 1930, and in Finland since 1940. In Europe, the Arctic fox is a priority species under the Actions by the Community relating to the Environment (ACE). It is therefore to be given full protection. On St. Paul Island the declining Arctic fox population has currently no legal protection.

In Norway (Svalbard), Greenland, Canada, Russia, and Alaska, trapping is limited to licensed trappers operating in a defined trapping season. The enforcement of these laws appears to be uniformly good. In Iceland, bounty hunting takes place over most of the country outside nature reserves.

Conservation measures taken An action plan has been developed for Arctic foxes in Sweden (Löfgren and Angerbjörn 1998) and status reports have been published for Norway (Frafjord and Rofstad 1998) and Finland (Kaikusalo *et al*. 2000). In Sweden and Finland, a conservation project is under way (SEFALO). In 1993, Mednyi Island gained protected status as a Nature Reserve.

Occurrence in captivity
The Arctic fox occurs widely in captivity on fur farms and has been bred for fur production for over 70 years. The present captive population originates from a number of wild populations and has been bred for characteristics different from those found in the wild, including large size. Escaped "blue" foxes may already be a problem in Fennoscandia (and to a lesser extent in Iceland) due to gene swamping (Hersteinsson *et al.* 1989).

Current or planned research projects
There are a large number of projects currently underway (or planned initiatives) across the distribution range.

A. Angerbjörn, M. Tannerfeldt, B. Elmhagen, and L. Dalén (Stockholm University, Sweden) are studying conservation genetics, predation patterns, and relationships between red and Arctic foxes in Fennoscandia.

N. Eide (Norwegian Polar Institute Tromsø, Norway) is exploring habitat use and population ecology of Arctic foxes in Svalbard.

E. Fuglei (Norwegian Polar Institute, Tromsø, Norway) is investigating the ecophysiology and genetics of Arctic foxes at Svalbard, as well as the effects of persistent organic pollutants in the Arctic fox.

P. Prestrud (Norwegian Polar Institute, Tromsø) continues long-term population monitoring of Arctic foxes in Svalbard.

K. Frafjord (Tromsø University, Norway) is looking at the ecology of Arctic fox dens and patterns of den use by Arctic and red foxes in northern Norway.

J. Linnell (Strand Olav, NINA, Norway) is studying captive breeding and behavioural ecology of Arctic foxes in Norway.

P. Hersteinsson (University of Iceland) is researching juvenile dispersal, including timing and mode of dispersal and dispersal distance in western Iceland.

Multiple researchers, including E. Fuglei (Norwegian Polar Institute Tromsø, Norway), E. Geffen and M. Kam (University of Tel Aviv, Israel), A. Angerbjörn (Stockholm University, Sweden) and P. Hersteinsson (University of Iceland) are investigating the energy costs of parental care in free-ranging Arctic foxes across the species' range.

G. Samelius (University of Saskatchewan, Canada) is studying population ecology, and the relationship of Arctic foxes to Arctic geese in the Queen Maud Gulf Bird Sanctuary in Nunavut, Canada.

P. White (Museum of Vertebrate Zoology, University of California, Berkeley, California, USA) is studying behavioural ecology, disease, and organochlorine contaminants of Arctic foxes on St. Paul Island.

R.K. Wayne and C. Vila (University of California, Los Angeles, California, USA) are undertaking an investigation into the population genetics of the species.

M. Zakrzewski and B. Sittler (University of Freiburg, Germany) study population dynamics in North-east Greenland.

Gaps in knowledge
1. Little is known concerning the impact of diseases introduced by humans on fox populations. Allied to this is our lack of knowledge of the epidemiology of Arctic rabies.
2. Considering the northward spread of the red fox in certain areas, studies are necessary to determine the effects of competition between red foxes and Arctic foxes on various population parameters and Arctic fox life-history patterns.
3. The non-recovery of the Fennoscandian population is a cause for concern, and requires specific attention, especially in terms of disease and genetics.

Core literature
Angerbjörn *et al*. 1995; Audet *et al.* 2002; Eberhardt *et al*.1982, 1983; Frafjord and Prestrud 1992; Garrott and Eberhardt 1982, 1987; Hersteinsson *et al*. 1989; Hersteinsson and Macdonald 1982, 1992; Macpherson 1969; Nasimovic and Isakov (eds). 1985; Tannerfeldt and Angerbjörn 1998.

Reviewers: Karl Frafjord, Gustaf Samelius, Pål Prestrud, Paula White. **Editors:** Deborah Randall, Michael Hoffmann, Claudio Sillero-Zubiri.

5.2 Grey wolf
Canis lupus Linnaeus, 1758
Least Concern (2004)

L.D. Mech and L. Boitani

Other names
English: timber wolf, tundra wolf, plains wolf, Mexican wolf, Arctic wolf; **Albanian:** ujku; **Croatian:** vuk; **Czech:** vlk; **Danish and Norwegian:** ulv; **Dutch:** wolf; **Estonian:** hunt, susi; **Faeroese:** ulvur, fjallaúvur; **Finnish:** susi; **French:** loup; **German:** wolf; **Hungarian:** farkas; **Icelandic:** úlfur; **Italian:** lupo; **Latvian:** vilks; **Lithuanian:** vilkas; **Maltese:** lupu; **Polish:** wilk; **Portuguese:** lobo; **Romanian:** lup; **Russian:** wilk; **Slovakian:** vlk dravý; **Slovenian:** volk; **Spanish:** lobo; **Swedish:** varg; **Turkish:** kurt; **Indigenous names:** Arapaho: haqihana; Caddo: tasha; Navaho: mai-coh; Nunamiut: amaguk (USA).

Taxonomy
Canis lupus Linnaeus, 1758. Syst. Nat., 10th ed., 1:39. Type locality: "Europæ sylvis, etjam frigidioribus"; restricted by Thomas (1911) to "Sweden".

Two recent proposals have been made for major taxonomic changes in the grey wolf in North America: Nowak (1995) presented data reducing the 24 North American subspecies to five; and Wilson *et al.* (2000), using molecular genetics data, proposed that wolves in eastern North America had evolved in North America contrary to wolves elsewhere that evolved in Eurasia and spread to North America. The authors proposed the name *Canis lycaon* for the wolf that they believe evolved in North America.

Chromosome number: 2n=78 (Wayne 1993).

Note: The Wolf Specialist Group has not taken a position on whether *Canis aureus lupaster* is a grey wolf (see Ferguson 1981), or whether *Canis lycaon* (Wilson *et al.* 2000) is valid.

Description
The grey wolf is the largest wild canid weighing up to 62kg (Table 5.2.1). General appearance and proportions are not unlike a large German shepherd dog except legs longer,

Table 5.2.1 Body measurements for the grey wolf.
Wolf body measurements vary greatly. Examples from Wrangel, Alaska, USA (Young and Goldman 1944:454).

HB+T male	1,650mm
HB+T female	1,585mm
T male	453mm
T female	435mm
HF male	298mm
HF female	279mm

Adult female Mexican wolf. San Cayetano breeding facility, Mexico State, Mexico, 1992.

Rurik List

feet larger, ears shorter, eyes slanted, tail curled, and winter fur longer and bushier, and with chin tufts in winter. Fur is thick and usually mottled grey, but can vary from nearly pure white, red, or brown to black. Dental formula 3/3-1/1-4/4-2/3=42.

Subspecies See Nowak (1995) for maps and measurements of seven Eurasian and five North American subspecies:
— *C. l. albus* (northern Russia)
— *C. l. arctos* (Canadian High Arctic)
— *C. l. baileyi* (Mexico, south-western USA)
— *C. l. communis* (central Russia)
— *C. l. cubanensis* (east central Asia)
— *C. l. hattai* (Hokkaido, Japan)
— *C. l. hodophilax* (Honshu, Japan)
— *C. l. lupus* (Europe, Asia)
— *C. l. lycaon* (south-eastern Canada, north-eastern USA)
— *C. l. nubilis* (central USA, east-central Canada)
— *C. l. occidentalis* (Alaska, north-western Canada)
— *C. l. pallipes* (Middle East, south-western Asia)

Similar species Red wolf (*C. rufus*): slightly smaller than *C. lupus*. Coyote (*C. latrans*): about one-third to one-half size of *C. lupus*. Golden jackal (*C. aureus*): about one-third size of *C. lupus*.

Distribution

Historical distribution Originally, the wolf was the world's most widely distributed mammal, living throughout the northern hemisphere north of 15°N latitude in North America and 12°N in India. It has become extinct in much of Western Europe (Boitani 1995), in Mexico and much of the USA (Mech 1970).

Current distribution Present distribution is more restricted; wolves occur primarily in wilderness and remote areas, especially in Canada, Alaska and northern USA, Europe, and Asia from about 75°N to 12°N (Figure 5.2.1).

Range countries Afghanistan, Albania, Armenia, Azerbaijan, Belarus, Bhutan, Bosnia Herzegovina, Bulgaria, Canada, China, Croatia, Czech Republic, Denmark (Greenland), Estonia, Finland, France, Germany, Georgia, Greece, Hungary, India, Iran, Iraq, Israel, Italy, Jordan, Kazakhstan, Korea, Kyrgyztan, Latvia, Lebanon, Lithuania, Macedonia, Mexico, Moldova, Mongolia, Montenegro, Myanmar, Nepal, Norway, Oman, Pakistan, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovakia, Slovenia, Spain, Sweden, Syria, Tajikistan, Turkey, Turkmenistan, Uzbekistan, Ukraine, United Arab Emirates, United States of America, Yemen, Yugoslavia (Montenegro, Kosovo and Serbia) (Mivart 1890; Ognev 1931; Pocock 1935; Young and Goldman 1944; Mech 1970, 1974; Mech and Boitani 2003).

Relative abundance

Because of the diversity in climate, topography, vegetation, human settlement and development of wolf range, wolf populations in various parts of the original range vary from extinct to relatively pristine. Wolf densities vary from about $1/12km^2$ to $1/120km^2$.

Estimated populations/relative abundance and population trends Details are provided below on subspecies present, population status, approximate numbers, the percentage of former range occupied at present, main prey (where known), legal status, and cause of decline. Countries (provinces, states or regions whenever appropriate) are listed by geographical region and roughly follow a west to east and north to south order.

North America (Nearctic)

— *Alaska (USA)*: Subspecies: *C. l. occidentalis*. Status: Fully viable, about 6,000. Former range occupied: 100%. Main prey: Moose, caribou, sheep, deer, beaver, goat. Legal status: Animals are hunted and trapped in limited seasons with bag limits. Some control work, enforcement active.
— *British Columbia (Canada)*: Subspecies: *C. l. occidentalis*, *C. l. nubilus*. Status: Fully viable, about 8,000. Range occupied: 80%. Main prey: Moose, caribou, sheep, deer, beaver, goat, elk. Legal status: Game species, furbearer, no closed season.
— *Yukon Territory (Canada)*: Subspecies: *C. l. occidentalis*. Status: Fully viable, about 4,500. Range
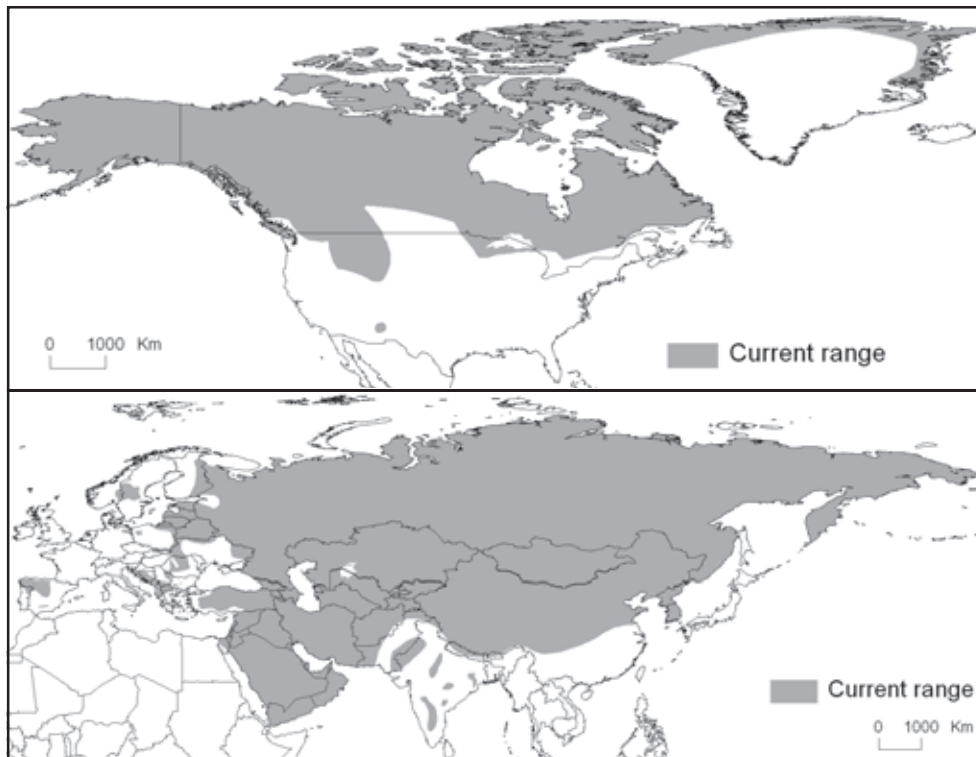

Figure 5.2.1. Current distribution of the grey wolf.

occupied: 100%. Main prey: Moose, caribou, sheep, deer, beaver, goat, elk. Legal status: Game species, furbearer, no closed season.

— *North-west Territories and Nunavut (Canada)*: Subspecies: *C. l. arctos, C. l. nubilus, C. l. occidentalis*. Status: Fully viable, about 10,000. Range occupied: 100%. Main prey: Moose, caribou, musk oxen, sheep, beaver, goat. Legal status: Furbearer.

— *Greenland (Denmark)*: Subspecies: *C. l. arctos*. Status: Threatened, lingering at 50? Range occupied: Unknown. Main prey: Musk oxen, lemmings, arctic hares. Legal status: Unknown. Cause of decline: Persecution.

— *Alberta (Canada)*: Subspecies: *C. l. occidentalis*. Status: Fully viable, about 4,000. Range occupied: 80%. Main prey: Moose, caribou, sheep, deer, beaver, goat, elk, bison. Legal status: Furbearer.

— *Saskatchewan (Canada)*: Subspecies: *C. l. occidentalis, C. l. nubilis*. Status: Fully viable, about 4,300. Range occupied: 70%. Main prey: Moose, elk, deer, beaver, bison, caribou. Legal status: Furbearer.

— *Manitoba (Canada)*: Subspecies: *C. l. occidentalis, C. l. nubilis*. Status: Fully viable, about 5,000. Range occupied: 50%. Main prey: Moose, elk, deer, beaver, caribou. Legal status: Furbearer.

— *Ontario (Canada)*: Subspecies: *C. l. lycaon, C. l. nubilis* (but see Taxonomy). Status: Fully viable, <8,500. Range occupied: 80%. Main prey: Moose, deer, caribou, beaver. Legal status: Furbearer.

— *Quebec (Canada)*: Subspecies: *C. l. lycaon, C. l. nubilis* (but see Taxonomy). Status: Fully viable, number unknown but probably thousands. Range occupied: 80%. Main prey: Moose, deer, caribou, beaver. Legal status: Furbearer.

— *Labrador (Canada)*: Subspecies: *C. l. nubilis*. Status: Fully viable, 1,000–5,000. Range occupied: 95%. Main prey: Moose, caribou, beaver, musk oxen, hares. Legal status: Furbearer.

— *Newfoundland (Canada)*: Subspecies: *C. l. nubilis*, extinct since 1911.

— *North-western USA*: Subspecies: *C. l. occidentalis* (reintroduced in Wyoming and Idaho). Status: Increasing, about 400, Endangered. Range occupied: 20%. Main prey: Elk, moose, sheep, goats, deer, beaver. Legal status: Full protection, except for government reactive depredation control.

— *Minnesota (USA)*: Subspecies: *C. l. nubilis* (but see Taxonomy). Status: Viable, about 2,600. Range occupied: 40%. Main prey: Deer, moose, beaver. Legal status: Full protection, except for reactive government depredation control.

— *Michigan and Wisconsin (USA)*: Subspecies: *C. l. nubilis* (but see Taxonomy). Status: Increasing, about 400. Range occupied: 25%. Main prey: Deer, beaver, moose. Legal status: Full protection.

— *South-western USA*: Subspecies: *C. l. baileyi*. Status: Reintroduced (about 25 in 2000). Range occupied: <5%. Main prey: Deer, elk, livestock. Legal status: Full protection. Cause of decline: Persecution, habitat destruction.

— *Mexico*: Subspecies: *C. l. baileyi*. Status: Highly endangered. Possibly lone wolves or pairs, <10. Range occupied: <10%. Main prey: Livestock. Legal status: Full protection, but not enforced. Cause of decline: Persecution, habitat destruction.

Europe (Palaearctic)

— *Norway*: Subspecies: *C. l. lupus*. Status: About 20. Range occupied: 5%. Main prey: Ungulates and livestock. Legal status: Protected. Threat: Culling.

— *Sweden*: Subspecies: *C. l. lupus*. Status: Increasing, about 100. Range occupied: 20%. Main prey: Ungulates. Legal status: Protected.

— *Finland*: Subspecies: *C. l. lupus*. Status: About 100. Range occupied: 20%. Main prey: Ungulates and livestock. Legal status: Partial protection.

— *Estonia, Latvia, Lithuania*: Subspecies: *C. l. lupus*. Status: Viable, about 2,000, stable. Range occupied: 75%. Main prey: Ungulates and livestock. Legal status: Hunted as game species. Threat: Overhunting, habitat destruction.

— *Russia (Europe), Belarus, Ukraine*: Subspecies: *C. l. lupus, C. l. albus*. Status: Fully viable, about 20,000. Range occupied: 60%. Main prey: Ungulates, livestock. Legal status: Reduction and control even in nature reserves. Cause of decline: Persecution, habitat destruction.

— *Poland*: Subspecies: *C. l. lupus*. Status: Viable, about 600. Range occupied: 50%. Main prey: Moose, roe deer, red deer, wild boar, mufflon. Legal status: Protected. Threat: Persecution, habitat destruction.

— *Czech Republic*: Subspecies: *C. l. lupus*. Status: Increasing, 20. Range occupied: 5%. Main prey: Ungulates and livestock. Legal status: Protected. Threat: Persecution.

— *Slovakia*: Subspecies: *C. l. lupus*. Status: Stable, 350–400. Range occupied: 50%. Main prey: Roe deer, red deer, wild boar. Legal status: Protected. Cause of decline: Persecution, habitat destruction.

— *Hungary*: Subspecies: *C. l. lupus*. Status: Stable, <50. Range occupied: 5%. Main prey: Unknown. Legal status: Protected. Threat: Habitat suitability.

— *Romania*: Subspecies: *C. l. lupus*. Status: Increasing, 2,500. Range occupied: 80%. Main prey: Roe deer, red deer, wild boar, livestock. Legal status: Protected.

— *Bulgaria*: Subspecies: *C. l. lupus*. Status: Increasing, 800–1,000. Range occupied: 40%. Legal status: Game species. Main prey: Roe deer, red deer, wild boar.

— *Greece*: Subspecies: *C. l. lupus*. Status: In decline, >500. Range occupied: 50%. Main prey: Deer, wild boar,

chamois, livestock. Legal status: Partial protection. Cause of decline: Persecution, habitat destruction.

— *Former Yugoslav Federation*: Subspecies: *C. l. lupus*. Status: Stable, about 500. Range occupied: 55%. Main prey: Deer, wild boar, livestock. Legal status: Partial protection. Threat: Persecution, habitat destruction.

— *Croatia and Slovenia*: Subspecies: *C. l. lupus*. Status: 150–200. Range occupied: 30%. Main prey: Ungulates and livestock. Legal status: Fully protected. Threat: Illegal persecution.

— *Albania*: Subspecies: *C. l. lupus*. Status: 250. Range occupied: 50%. Main prey: Deer and wild boar, livestock. Legal status: Hunted as game species. Cause of decline: Overhunting.

— *Former Yugoslav Republic of Macedonia*: Subspecies: *C. l. lupus.* Status: Viable, about 1,000. Range occupied: 75%. Main prey: Ungulates and livestock. Legal status: Hunted. Cause of decline: Persecution, habitat destruction.

— *Bosnia Herzegovina*: Subspecies: *C. l. lupus*. Status: Stable?, about 500. Range occupied: 50%. Main prey: Ungulates and livestock. Legal status: Hunted as game species. Threat: Persecution, habitat destruction.

— *Spain*: Subspecies: *C. l. lupus*. Status: Increasing, 2,000. Range occupied: 30%. Main prey: Livestock, roe deer, wild boar. Legal status: Partial protection. Threat: Persecution, habitat destruction.

— *Portugal*: Subspecies: *C. l. lupus*. Status: Stable, lingering, low population density, 200–300. Range occupied: 20%. Main prey: Livestock, roe deer, wild boar. Legal status: Protected. Threat: Persecution, habitat destruction.

— *France*: Subspecies: *C. l. lupus*. Status: Increasing, about 30. Range occupied: 5%. Main prey: Ungulates and livestock. Legal status: Protected. Threat: Persecution.

— *Italy*: Subspecies: *C. l. lupus*. Status: Increasing, 500 individuals. Threatened. Range occupied: 25%. Main prey: Wild boar, deer, livestock, garbage. Legal status: Full protection, not enforced. Threat: Persecution.

North and Central Asia (Palaearctic)

— *Former USSR*: Subspecies: *C. l. lupus, C. l. albus*. Status: Fully viable, about 50,000. Range occupied: 75%. Main prey: Ungulates and livestock. Legal status: Reduction and control even in nature reserves. Threat: Persecution, habitat destruction.

— *Turkmenistan*: Subspecies: *C. l. lupus*. Status: Viable, >1,000. Range occupied: 85%. Main prey: Ungulates and livestock. Legal status: Reduction and control even in nature reserves. Threat: Active persecution, habitat destruction.

— *Mongolia*: Subspecies: *C. l. lupus*. Status: Viable, possible decline, >10,000. Range occupied: 100%. Main prey: Livestock, saiga. Legal status: Extermination efforts active.

— *China*: Subspecies: *C. l. lupus*. Status: Stable, about 6,000. Range occupied: 20%. Main prey: Saiga, other ungulates, livestock. Legal status: Protected but no enforcement. Threat: Persecution, habitat destruction, extermination efforts active.

Middle East (Palaearctic)

— *Egypt (Sinai)*: Subspecies: *C. l. pallipes*. Status: Highly endangered, 30?. Range occupied: 90%. Main prey: Hares, livestock. Legal status: No protection. Cause of decline: Persecution.

— *Turkey*: Subspecies: *C. l. lupus, C. l. pallipes*. Status: Viable, but in decline. 5,000–10,000. Range occupied: 75% of former range. Main prey: Livestock, wild boar, brown hare. Legal status: No protection. Cause of decline: Persecution, poisoning.

— *Lebanon*: Subspecies: Unknown. Status: Highly endangered. Lone wolves or pairs, >10.. Range occupied: Unknown. Main prey: Garbage, carrion. Legal status: No protection. Cause of decline: Persecution.

— *Syria*: Subspecies: *C. l. lupus, C. l. pallipes*. Status: Highly threatened. Lingering, low population density, 200–300? Range occupied: 10%. Main prey: Livestock, carrion, small wildlife. Legal status: No protection. Threat: Persecution.

— *Jordan*: Subspecies: Unknown. Status: Highly threatened. Lingering, low population density, 200? Range occupied: 90%. Legal status: No protection. Main prey: Unknown. Threat: Persecution.

— *Israel*: Subspecies: *C. l. pallipes, C. l. arabs*. Status: Highly threatened. Lingering, low population density, 150–200. Range occupied: 60%. Main prey: Hares, livestock, carrion. Legal status: Full protection. Cause of decline: Habitat destruction.

— *Saudi Arabia, United Arab Emirates, Oman, Yemen*: Subspecies: *C. l. pallipes*. Status: In decline, 500–600. Range occupied: 75%. Main prey: Garbage, carrion, livestock. Legal status: No protection. Threat: Persecution.

— *Iraq*: Subspecies: Unknown. Status: Unknown. Range occupied: Unknown. Main prey: Unknown. Legal status: Unknown. Cause of decline: Unknown.

— *Iran*: Subspecies: *C. l. pallipes*. Status: Viable >1,000. Range occupied: 80%. Main prey: Gazelle, mountain sheep, livestock, wild boar, deer, *Capra* sp. Legal status: Game species. Threat: Persecution.

— *Afghanistan*: Subspecies: *C. l. pallipes*. Status: Viable, suspected decline, 1,000? Range occupied: 90%. Main prey: Unknown. Legal status: Unknown.

South Asia – south of the Himalaya (Oriental)

— *Pakistan*: Subspecies: *C. l. pallipes*. Status: Declining, 200. Range occupied: 10%. Main prey: Livestock, gazelle. Legal status: Protected, no enforcement. Cause of decline: Active persecution.

— *India*: Subspecies: *C. l. pallipes*. Status: Endangered. 1,000–2,000 in small fragmented populations. Range occupied: 20%. Main prey: Livestock, hare, deer, antelope. Legal status: Full protection, but not enforced. Cause of decline: Decreasing prey, habitat loss, persecution.
— *Nepal*: Subspecies: *C. l. lupus.* Status: Unknown. Range occupied: Unknown. Main prey: Unknown. Legal status: Unknown.
— *Bhutan*: Subspecies: *C. l. lupus*. Status: Unknown. Range occupied: Unknown. Main prey: Unknown. Legal status: Protected.

Habitat
All northern habitats where there is suitable food (Mech 1970), densities being highest where prey biomass is highest (Fuller 1989).

Food and foraging behaviour
Food Extremely variable, but the majority is large ungulates (moose, caribou, deer, elk, wild boar, etc.). Wolves will also eat smaller prey items, livestock, carrion, and garbage.

Foraging behaviour In winter, wolves hunt in packs, which are usually families, but in summer, they hunt singly, in pairs, or in small groups. Chases ranging from 100m to more than 5km are the rule, and generally wolves end up with, or tend to select, older individuals, young-of-the-year, debilitated animals, or those in otherwise poor condition (Mech and Boitani 2003). Average daily food consumption varies from 2.5–6.3kg or more per day, and kill rates vary accordingly. Wolves first attack the rump of larger prey, but the head, shoulders, flanks, or rump of smaller prey. Usually they eat most of the carcass, leaving only the larger bones and chunks of hide. When there is surplus food, wolves will cache either regurgitated chunks or large pieces (Mech and Boitani 2003).

Damage to livestock and game Wolves sometimes come into conflict with ranchers (Young and Goldman 1944; Mech 1970) and can reduce wild prey (Mech and Karns 1977).

Adaptations
The grey wolf is well adapted for cursorial predation, having long legs and thick and blocky, but flexible, feet. Year-round pair bond insures that more hunting units include at least two adults.

Social behaviour
Wolves are pack-living animals, with most packs comprising family groups. The dominant pair breeds, with any maturing females reproductively suppressed unless food is abundant. Packs include up to 36 individuals, but smaller sizes (5–12) are more common. They occupy territories of 75–2,500km² depending on prey density, and these are maintained through howling, scent-marking, and direct killing (Mech 1970, 1974; Mech *et al.* 1998).

Reproduction and denning behaviour
Time of mating is from January to April, depending on latitude (Mech 2002). Gestation is nine weeks. Dens are in holes, caves, pits, hollow logs, etc. Litter size is 1–11 (mean=6). Duration of lactation is 8–10 weeks. Age at sexual maturity is 22–46 months, occasionally 10 months (Mech 1970, 1974).

Competition
Bears, cougars, tigers, dogs (Mech 1970; Mech and Boitani 2003).

Mortality and pathogens
Natural sources of mortality Primarily intraspecific strife and starvation.

Persecution Primarily in agricultural areas where competing with humans for domestic animals.

Hunting and trapping for fur Primarily Alaska, Canada, Russia, Kazakhstan, Mongolia.

Road kills Not significant to populations.

Pathogens and parasites Susceptible to mange, canine parvovirus, distemper, rabies.

Longevity Up to 13 years in the wild, and 16 years in captivity (Mech 1988).

Historical perspective
The primary cultural importance of the wolf has been as an enemy seen by most agricultural people as a creature to be feared, persecuted and extirpated. Some indigenous people in North America, however, respected the wolf, although they still killed it. Most cultures used its fur as parkas and clothing. Conservation measures were not taken in most areas until after about 1970 and are still lacking in most of Asia, where they mostly are unnecessary, except in parts of China and India.

Conservation status
Threats Their original worldwide range has been reduced by about one-third, primarily in developed areas of Europe, Asia, Mexico, and the United States by poisoning and deliberate persecution due to depredation on livestock. Since about 1970, legal protection, land-use changes, and rural human population shifts to cities have arrested wolf population declines and fostered natural recolonisation in parts of Western Europe and the United States, and

reintroduction in the western United States. Continued threats include competition with humans for livestock, especially in developing countries, exaggerated concern by the public concerning the threat and danger of wolves, and fragmentation of habitat, with resulting areas becoming too small for populations with long-term viability.

Commercial use Sustainable utilisation of fur in Canada, Alaska, and the former Soviet Union and Mongolia.

Occurrence in protected areas Occurs in many protected areas across its range.

Protection status CITES – Appendix II, except populations from Bhutan, India, Nepal and Pakistan, which are listed on Appendix I. See individual countries listed above.

Current legal protection Variable, from complete protection, well enforced, to concerted efforts to control some populations. See individual areas above.

Conservation measures taken Protected in various national parks and reserves in Canada and the United States. Extensive legal protection in many European countries; however, enforcement is variable and often non-existent. See individual areas above. Recently reintroduced to Yellowstone National Park, Idaho, and Arizona.

Occurrence in captivity
Lives and breeds well in captivity and is common in many zoological gardens.

Current or planned research projects
Several projects underway in Europe, India, Canada and the United States. See http://www.wolf.org

Gaps in knowledge
One of the most important questions still remaining about wolves involves the nature of their interaction with prey populations. The conditions under which wolves limit, regulate, or control their population is still open and important (Mech and Boitani 2003). Of more academic interest are questions involving wolf genetics, scent-marking behaviour, pseudopregnancy, and diseases (Mech 1995a).

Core literature
Boitani 1995; Carbyn *et al.* 1995; Harrington and Paquet 1982; Mech 1970, 1974; Mech *et al.* 1998; Mech and Boitani 2003; Nowak 1995. A list of about 2,000 references is available at http://www.wolf.org

Reviewers: Lu Carbyn, Christoph Promberger, Devra Kleiman. **Editors:** Claudio Sillero-Zubiri, Michael Hoffmann.

5.3 Red fox
Vulpes vulpes Linnaeus, 1758
Least Concern (2004)

D.W. Macdonald and J.C. Reynolds

Other names
English: silver fox, cross fox; **Albanian:** dhelpra; **Croatian:** lisica; **Czech:** liška obecná; **Danish:** ræv; **Dutch:** vos; **Estonian:** rebane; **Faeroese:** revur; **Finnish:** kettu; **French:** renard roux; **German:** rotfuchs; **Hungarian:** vörös róka; **Irish:** sionnach, madra rua; **Italian:** volpe rossa, volpe comune; **Latvian:** lapsa; **Lithuanian:** rudoji lapë; **Luxembourgish:** fuuss; **Maltese:** volpi; **Norwegian:** rev, rødrev; **Polish:** lis; **Portuguese:** raposa; **Romanian:** vulpe; **Russian:** Красная дисица; **Slovakian:** líška hrdzavá; **Slovenian:** lisica; **Spanish:** zorro rojo; **Swedish:** räv; **Turkish:** tilki.

Taxonomy
Vulpes vulpes Linnaeus, 1758. Syst. Nat., 10th ed., 1:40. Type locality: "Europa, Asia, Africa, antrafodiens" restricted by Thomas (1911), to "Sweden (Uppsala)".

The North American red fox, *Vulpes fulva*, previously has been considered a separate species (as have some other putative subspecies), but is now considered conspecific with the Palaearctic *V. vulpes* (Nowak 1991). Many subspecies were described (see below) on the basis of regional variation, but these have doubtful ecological significance as evidenced by successful introductions and re-introductions around the world.

Chromosome number: The red fox has a diploid number of 34 chromosomes and 3–5 microsomes (Rausch and Rausch 1979).

Description
A medium-sized canid, and the largest fox in the genus *Vulpes* (Table 5.3.1). Muzzle slender and pointed with white on upper lip. Ears large, pointed, erect and black-backed. Pelage is reddish-brown but may vary from brown to russet red to yellowish grey. Three main colour morphs: red, silver (black with variable amount of frosting due to silver tips on guard hairs) and cross (greyish brown with long black guard hairs down back and across shoulders) (Banfield 1987; Johnson and Hersteinsson 1993). Some individuals have dark grey-black under throat and belly and the underfur of females during the breeding season may appear pink-tinged. Throat and/or chest may have white markings. Legs long and slender. Lower legs black, may be splashed with white. Tail long, thick and bushy, sometimes with white tip. Enormous geographical variation in size. Adult head and body length may range from 455–900mm, tail length from 300–555mm and body weight from 3–14kg with males generally being larger than females (Nowak 1991). The species is substantially smaller in the

Table 5.3.1. Body measurements for the red fox.

	Several studies from Cavallini (1995)	Ontario, Canada (Voigt 1987)	Canberra, Australia (McIntosh 1963)	Kent, UK (Hatting 1956)	Hokkaido, Japan (Zhan et al. 1991)
Total length male		1,026mm n=37	1,048mm n=84	1,064mm n=9	
Total length female		973mm n=34	1,002mm n=60	1,022mm n=10	
HB male	660mm (590–720) n=11 (studies)				
HB female	630mm (550–680) n=11				
T male	400mm (360–440) n=11				
T female	370mm (280–490) n=11				
WT male	6.3kg (4.4–7.6) n=20	4.1kg (n=37)	6.3kg (n=84)	6.7kg (n=33)	8.7kg (n=20)
WT female	5.3kg (3.6–6.5) n=20	3.4kg (n=37)	5.5kg (n=60)	5.5kg (n=29)	6.1kg (n=25)

Adult male red fox. United Kingdom.

David Macdonald

Middle East deserts (Macdonald *et al.* 1999) than in Europe. Smaller also in North America (Voigt 1987). Skull measurements of specimens from northern Algeria are also much smaller than central European populations (Kowalski and Rzebik-Kowalska 1991). Dental formula 3/3-1/1-3/4-3/3=42.

Red foxes from North America are comparatively light, rather long for their mass, and with a high sexual dimorphism. British foxes are heavier but relatively short. European foxes are closer to the general average among populations. Additionally, body mass and length are positively related to latitude (i.e., follow Bergmann's Rule), but this is a smaller effect than that related to geographical origin.

Subspecies Larivière and Pasitschniak-Arts (1996) recognised 44 subspecies, although many are doubtful:
— *V. v. abietorum* (Stuart Lake, British Columbia, Canada)
— *V. v. aegyptiaca* (Egypt)
— *V. v. alascensis* (Andreafski, Alaska, USA)
— *V. v. alpherakyi* (Geok Tepe, Araisk, Kazakhstan)
— *V. v. anatolica* (Smyrna, western Asia Minor, Turkey)
— *V. v. arabica* (Muscat, Oman)
— *V. v. atlantica* (Atlas Mountains, Mitiya, Algeria)
— *V. v. bangsi* (L'Anse au Loup, Strait of Belle Isle, Labrador, Canada)
— *V. v. barbara* (Barbary Coast, north-western Africa)
— *V. v. beringiana* (shore of Bering Strait, north-eastern Siberia)
— *V. v. cascadensis* (Cascade Mountains, Skamania County, Washington, USA)
— *V. v. caucasica* (near Vladikawkaz, Caucasus, Russia)
— *V. v. crucigera* (Thuringia, Germany)
— *V. v. daurica* (Kharangoi, 45km west of Troizkosavsk, Siberia)
— *V. v. deletrix* (Bay St-George, Newfoundland, Canada)
— *V. v. dolichocrania* (Sidemi, southern Ussuri, SE Siberia)
— *V. v. flavescens* (northern Iran)
— *V. v. fulva* (Virginia, USA)
— *V. v. griffithii* (Kandahar, Afghanistan)

— *V. v. harrimani* (Kodiak Island, Alaska, USA)
— *V. v. hole* (near Amoy, Fukien, S. China)
— *V. v. ichnusae* (Sarrabus, Sardinia, Italy)
— *V. v. induta* (Cape Pyla, Cyprus)
— *V. v. jakutensis* (Taiga, south of Yakutsk, E. Siberia)
— *V. v. japonica* (Japan)
— *V. v. karagan* (Kirghiz Steppes, Khirghizia, Russia)
— *V. v. kenaiensis* (Kenai Peninsula, Alaska, USA)
— *V. v. kurdistanica* (Gelsk Valley, NE Turkey)
— *V. v. macroura* (Wasatch Mountains, near Great Salt Lake, Utah, USA)
— *V. v. montana* (Himalaya)
— *V. v. necator* (Whitney Meadow, near Mt Whitney, Tulare County, California, USA)
— *V. v. ochroxantha* (Aksai, Semirechyia, E Russian Turkestan, Kirgizia)
— *V. v. palaestina* (Ramleh, near Jaffa, Occupied Palestinian Territory)
— *V. v. peculiosa* (Korea)
— *V. v. pusilla* (Salt Range, Punjab, Pakistan)
— *V. v. regalis* (Elk River, Sherburne County, Minnesota, USA)
— *V. v. rubricosa* (Digby, Nova Scotia, Canada)
— *V. v. schrencki* (Sakhalin, Russia)
— *V. v. silacea* (near Silos, Burgos, Spain)
— *V. v. splendidissima* (north and central Kurile Islands, Russia)
— *V. v. strepensis* (steppes near Kherson, Russia)
— *V. v. tobolica* (Obdorsk, Tobolsk, Siberia)
— *V. v. tschiliensis* (Peiping, Chihli, NE China)
— *V. v. vulpes* (Sweden)

Similar species Arctic fox (*Alopex lagopus*): A white morph superficially resembles white red foxes (some of which are albino) but they are up to 25% smaller, with muzzle shorter and ears shorter and rounder. Similarly,

"silver" (actually black) or "cross" red foxes might be confused with blue morph of Arctic foxes.

Grey wolf (*Canis lupus*), and golden jackal (*Canis aureus*), are larger, have longer legs and relatively shorter tail. Confusion of pelts with those of smaller species more likely, due to clinal variation in body size and coloration between the largest red foxes (probably those in Scotland), and the smallest (perhaps in remote Saudi Arabia).

Great potential for confusion between red fox pelts and all the small Old World foxes (e.g., Tibetan fox, *V. ferrilata*, and corsac, *V. corsac*), the prairie foxes of North America (*V. macrotis* and *V. velox*), and some South American foxes.

A mutant of the red fox found in the wild, the so-called "Samson fox", lacks guard hairs.

Current distribution

Distributed across the entire northern hemisphere from the Arctic Circle to North Africa, Central America, and the Asiatic steppes, the red fox has the widest geographical range of any member of the order Carnivora (covering nearly 70 million km²) (Figure 5.3.1). Not found in Iceland, the Arctic islands, some parts of Siberia, or in extreme deserts. European subspecies introduced into eastern United States and Canada in 17th century, subsequently mixed with local subspecies. The species was also introduced to Australia in 1800s. Elsewhere introduced to the Falkland Islands (Malvinas) and to the Isle of Man (UK), although it may subsequently have disappeared there.

Range countries Afghanistan, Albania, Algeria, Andorra, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Bulgaria, Cambodia (?), Canada, Channel Islands, China, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Faeroe Islands, Falkland

Figure 5.3.1. Current distribution of the red fox.

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Islands (Malvinas), Finland, France, Georgia, Germany, Gibraltar (?), Greece, French Guiana, Guyana, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kyrgyzstan, Korea (North and South), Kuwait, Laos PDR (?), Latvia, Lebanon, Libya, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta (?), Moldova, Monaco (?), Mongolia, Morocco, Myanmar, Nepal (?), Netherlands, Norway, Oman, Pakistan, Occupied Palestinian Territory, Poland, Portugal, Qatar, Romania, Russian Federation, San Marino, Saudi Arabia, Slovakia, Slovenia, Spain, Sudan, Suriname, Sweden, Switzerland, Syria, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uzbekistan, Vietnam (?), Yemen, Yugoslavia (Lloyd 1980, Macdonald and Barrett 1993, Larivière and Pasitschniak-Arts 1996).

Relative abundance

Red fox density is highly variable. In the UK, density varies between one fox per 40km² in Scotland and 1.17/km² in Wales, but can be as high as 30 foxes per km² in some urban areas where food is superabundant (Harris 1977, Macdonald and Newdick 1982, Harris and Rayner 1986). Social group density is one family per km² in farmland, but may vary between 0.2–5 families per km² in the suburbs and as few as a single family per 10km² in barren uplands (Macdonald 1981, Lindsay and Macdonald 1986).

Fox density in mountainous rural areas of Switzerland is 3 foxes per km² (Meia 1994). In northern boreal forests and Arctic tundra, they occur at densities of 0.1/km², and in southern Ontario, Canada at 1/km² (Voigt 1987). The average social group density in the Swiss mountains is 0.37 family per km² (Weber *et al*. 1999).

Estimated populations/relative abundance and population trends The pre-breeding British fox population totals an estimated 240,000 (195,000 in England, 22,000 in Wales; Harris *et al*. 1995). Mean number of foxes killed per unit area by gamekeepers has increased steadily since the early 1960s in 10/10 regional subdivisions of Britain, but it is not clear to what extent this reflects an increase in fox abundance. Although an increase in fox numbers following successful rabies control by vaccination was widely reported in Europe (e.g., fox bag in Germany has risen from 250,000 in 1982–1983 to 600,000 in 2000–2001), no direct measures of population density have been taken.

Habitat

Red foxes have been recorded in habitats as diverse as tundra, desert and forest, as well as in city centres (including London, Paris, Stockholm, etc.). Natural habitat is dry, mixed landscape, with abundant "edge" of scrub and woodland. They are also abundant on moorlands, mountains (even above the treeline, known to cross alpine passes), deserts, sand dunes and farmland from sea level to 4,500m a.s.l. In the UK, they generally prefer mosaic patchworks of scrub, woodland and farmland. Red foxes flourish particularly well in urban areas. They are most common in residential suburbs consisting of privately owned, low-density housing and are less common where industry, commerce or council rented housing predominates (Harris and Smith 1987). In many habitats, foxes appear to be closely associated with man, even thriving in intensive agricultural areas.

Food and foraging behaviour

Food Red foxes are adaptable and opportunistic omnivores, with a diet ranging from invertebrates (e.g., earthworms and beetles) to mammals and birds (including game birds), and fruit. They also scavenge in rural areas (e.g., in Europe and Canada on deer and sheep carcasses which may be the major food source in upland areas in winter), and in urban areas (on bird tables, compost heaps and refuse). As predators, foxes typically kill birds and mammals up to about 3.5kg (equivalent to an adult brown hare). They require about 500g food per day, caching food that is in excess to their requirements and having a highly developed memory for location of hoards (Macdonald 1976, 1977a).

Foraging behaviour Foraging is mainly nocturnal and crepuscular, although more diurnal where they are undisturbed. They are independent and thus generally solitary foragers, although individuals may forage in close proximity where resources are clumped. Accounts of cooperative hunting, for example of young ungulates have not been studied systematically (Macdonald 1980a).

Damage to livestock or game Foxes are considered a major predator of ground-nesting colonial birds such as terns (many species of which are of conservation concern), and their effect on harvestable game-bird populations can be significant. They also predate hand-reared and released game-birds. Lambs may be taken locally but losses caused by foxes are typically only a small percentage (<2%) of all lambs born (Macdonald *et al*. 2000).

Adaptations

Paradoxically, it is probably the red fox's generalist conformation and lack of specialist adaptations that makes it the widely successful species that it is. The weakest element in this general formula, exploited by man and other predators, is the period of vulnerability of the young at the breeding den.

The red fox has great endurance and can gallop for several kilometres if pursued, they are able to run at speeds of up to 48km/h, jump fences two metres high and swim well (Haltenorth and Roth 1968). Red foxes can locate sounds to within one degree at 700–3,000Hz, though

less accurately at higher frequencies. They are adapted to pounce on their prey with great precision, manipulating take-off angle to adjust length of jump and force of landing. They have relatively longer hind legs than other members of the dog family thereby increasing their propulsive force.

Dense, but short, fur covers approximately one-third of the body's surface area, particularly the face, dorsal part of head, nose, ears, lower legs and paws, and likely functions as a major heat exchange surface for thermoregulation (Klir and Heath 1992). The nose is used for evaporative cooling and probably forms part of a brain cooling mechanism as described in domestic dogs (Klir and Heath 1992). The physiology of their senses and their physical size and agility mean foxes are particularly well suited to preying on small rodents.

Red foxes can dig their own dens or may enlarge the burrows of other species, such as rabbits (*Oryctolagus cuniculus*), marmots (*Marmota* spp.), European badgers (*Meles meles*), or even other foxes. Dens normally are dug into banks, tree root systems, rocky crevices and even under buildings.

Social behaviour

The basic social unit is a pair, but groups with up to six members (usually one adult male and 2–5, probably related, vixens) may share a territory, depending on habitat. Range size is habitat dependent and can cover from less than 0.40km² (e.g., urban foxes in Oxford, UK), to as much as >40km² (>30km² in Arctic), depending on habitat (reviewed by Voigt and Macdonald 1984). One fox in the deserts of Oman had a range spanning 50km² (Lindsay and Macdonald 1986). There are reports of overlapping home ranges in some (but not all) urban (e.g., Harris 1979) and rural environments (Meia and Weber 1996) and drifting territories in other urban settings (Doncaster and Macdonald 1991).

Red foxes communicate with facial expressions, vocalisations and scent marking. Scent marking involves urine and faeces (urine marking is sometimes confined to dominant females within a group), anal sac secretions, violet or supracaudal gland (more active in males during breeding season) as well as glands around lips, in the angle of the jaw and between pads of the feet. Some 28 different categories of vocalisation have been described, and are used to communicate over long distances and at close quarters. Individuals have characteristically different voices.

Mating behaviour is highly variable, and may include monogamous pairs, a single male with two breeding vixens that may or may not share a communal den, to a single breeding female with several non-breeding female helpers. There is always only one breeding male in the group although additional matings do occur outside the group. Territorial male red foxes make frequent excursions beyond their territories during the mating season, during which itinerant males also make incursions into territories (Macdonald 1987).

Juveniles may disperse between six and 12 months of age, mostly between October and January. All or most males disperse but the proportion of each sex dispersing varies between habitats and may depend on extent of mortality (e.g., due to rabies or control). Males typically disperse further than females (e.g., males 13.7km, females 2.3km in Welsh hills; Lloyd 1980; Trewhella *et al*. 1988). Dispersal distance correlates positively with home range size (Macdonald and Bacon 1982). In the UK, distances are generally less than 5km to more than 50km, but distances up to 394km have been recorded in the USA (Ables 1975) to 250km in Sweden (Englund 1970).

Reproduction and denning behaviour

Males are seasonally fecund. Mating occurs between December and February (June to October in Australia); the onset of breeding is correlated with day length and so starts earlier at more southerly latitudes. Females are receptive over a period of three days. Following a gestation period of 49–55 days, births occur from March to May. Birth weight is around 100g. Underground dens are needed to shelter cubs while they are very young. Lactation lasts for four weeks, and the cubs are fully weaned at 6–8 weeks. Sexual maturity is reached at 9–10 months. The proportion of breeding females in the group, and litter size (3–12 young per litter, usually 4–5 in Europe, 6–8 in Ontario; Voigt and Macdonald 1984), varies with food availability. Fox populations that are dense relative to food resources are generally less productive than those that are less dense. A single litter per year is the norm.

In high-density red fox populations where interactions with the dominant vixen are high, subordinate females do not usually breed, although they may breed successfully in low-density populations (in the UK, usually only one or two females in a group breed) (Macdonald 1980b, 1987). Both parents, and sometimes other females in the group, care for the young (Macdonald 1979b). The male provides food to the lactating female which is generally confined to the den prior to weaning. Weaned food is provided for the cubs by both parents. Non-breeding females may also feed, groom and tend the cubs and have been known to adopt them if orphaned (Macdonald 1979b). If two females breed within a group, they may share a den and litters may be communally suckled.

There is socially-mediated suppression of reproduction amongst females, with lowest productivity tending to occur where fox density is high or food supply poor. Where food is not limited, social status itself can suppress reproduction, with only the dominant female breeding. Behavioural mechanisms by which this occurs include harassment of subordinates, infanticide and cannibalism of subordinate vixens' cubs, and possibly the dominant male courting only the dominant females (Macdonald

1977b, 1980). A hormonal mechanism whereby stress leads to lowered productivity through foetal reabsorption has also been identified (Hartley *et al.* 1994). Consistent with this mechanism, Heydon and Reynolds (2000) found that in populations where productivity was low, reproductive performance was suppressed consistently at all stages of pregnancy, from conception to birth.

Competition

Red foxes compete with Arctic foxes where the two species occur sympatrically in the Eurasian tundra. Red foxes are larger and generally out-compete Arctic foxes (and has been known to kill both adults and young), but are limited to the north of their range, partly by the cold and partly by limited resources. Although both species are well adapted to cold conditions, adaptations of Arctic foxes are superior: 70% Arctic fox pelage is underfur, *cf.* 20% in red foxes; the lower critical temperature for Arctic fox *c.* -40°C, *cf. c.* -13°C for red fox). Larger red foxes also have greater energy requirements and reach a point (as productivity decreases in the north) where they cannot maintain a large enough home range to provide sufficient prey (Hersteinsson and Macdonald 1982). See also *Alopex lagopus* account.

Grey wolves and red foxes were originally sympatric throughout their shared range, but there is little dietary overlap between the two, and they may or may not use different habitats. Similar diets between coyotes (*Canis latrans*) and red foxes lead to interference competition. In this case, the larger coyote tends to be distributed wherever there are sufficient food resources and no other limiting factors, while red foxes occupy adjacent areas with lower amounts of food resources. Red fox numbers tend to be greater where coyotes are absent and foxes do not rear cubs where coyotes are active (Voigt and Earle 1983). Ratio of coyotes to foxes is lower where wolves are present than where wolves are absent in the USA (Peterson 1995). Diets are also similar between red and gray foxes (*Urocyon cinereoargenteus*), which are similar in size. In this case, exploitative competition for food is likely and habitat partitioning common. There is some evidence that gray foxes, despite being smaller, dominate red foxes in parts of eastern North America (Follmann 1973, Tuller and Berchielle 1982). Red foxes also kill kit foxes (*Vulpes macrotis*) (Ralls and White 1995). Red foxes kill stone martens (*Martes foina*) in areas where they feed on similar resources (Weber *et al.* 2002). European badgers will charge and displace foxes at feeding sites (D. Macdonald pers. obs.).

Mortality and pathogens

Natural sources of mortality Red fox life-history patterns are typified by high juvenile and subordinate adult mortality and lower adult mortality. Although demography can differ markedly between populations,

roughly 75% of foxes die in their first year, and thereafter mortality is approximately 50% in each adult year.

Red foxes have few natural predators, although golden eagles (*Aquila chrysaetos*) may kill both cubs and adults, and badgers and domestic dogs may kill cubs. Red foxes are a regular prey of the Eurasian lynx (*Lynx lynx*) in the Swiss Jura Mountains (Jobin *et al.* 2000). In addition, coyotes and wolves have both been recorded killing adults and cubs (Voigt and Earle 1983; Pacquet 1992).

Persecution In the UK, people (through secondary poisoning, shooting and other methods of attempted control) are typically the major cause of fox mortality, which is especially high amongst dispersers. Foxes are widely culled as pests. In the UK, for instance, culling is widespread, though highly variable among regions in methods, intensity and impact (Heydon and Reynolds 2000). Shooting is the principal method. Controversially, foxes are also hunted with dogs in the UK, France, Belgium, Portugal, Italy, Germany, Switzerland, Australia, the USA and Canada. Mounted fox hunts, together with upland foot and gun packs, probably are responsible for the deaths of about 21,500–25,000 foxes annually in the UK, which at this national level is about 4% of total mortality (Macdonald *et al.* 2000). Reliable estimates of numbers dying through other individual causes not available (for example, the extent of both deliberate and secondary poisoning is largely unknown).

Hunter bags in other countries are: Germany 600,000 (2000–2001); Austria 58,000 (2000–2001); Sweden 58,000 (1999–2000); Finland 56,000 (2000–2001); Denmark 50,000 (1976–1977); Switzerland 34,832 (2001); Norway 17,000 (2000–2001); Saskatchewan (Canada) 2,000 (2000–2001); Nova Scotia (Canada) 491 (2000–2001); New Mexico (USA) 69 (1999–2000).

Hunting and trapping for fur Worldwide trade of wild-caught foxes in 1985–1986 was 1,543,995 pelts. In the USA, red fox made up 45% of trade in wild-caught pelts worth $50 million in 1983. Most red foxes are killed for a variety of reasons, of which their value as fur is only one.

Road kills Where road-traffic is a dominant feature in modern landscapes, many red foxes are killed by vehicles. Juvenile and dispersing (mostly juvenile male) foxes are thought to be particularly susceptible. The impact of this mortality on population dynamics is not clear, and in both urban and rural environments, red fox populations exist alongside heavy road traffic. Fox density among three regions of England and Wales matched variation in culling pressure but did not match variation in road traffic density (Heydon *et al.* 2000).

Pathogens and parasites Populations are locally and periodically reduced by rabies epizootics (mortality rates

estimated at 60–80% by simulation models; Voigt *et al.* 1985), although recovery appears to be swift (e.g., Western Europe, USA; Wandeler *et al.* 1974). Red foxes are a widespread reservoir of rabies, especially in central Europe, south-eastern Canada and north-eastern USA (Chomel 1993). Oral vaccines have been successfully used in some European countries (Kappeler *et al.* 1988) but there are still areas where rabies control has failed (Funk *et al.* 2001). Oral vaccination is regarded by the World Health Organization and European Union as an ongoing experiment. The red fox is host to a wide range of parasites including at least 58 species of helminths in Europe alone (Wolfe *et al.* 2001; Simpson 2002). One of the most serious of the parasites infecting foxes is the skin-dwelling mite (*Sarcoptes scabei* var. *vulpes*) which causes sarcoptic mange. This disease is locally and temporally prevalent. It appeared in Finland in 1967 and spread to Norway and Sweden in the 1970s and 1980s, where it reduced the red fox population by over 70% (Holt and Berg 1990; Lindström 1992). Since then it has spread across most of Europe including England, where it wiped out over 90% of the fox population in Bristol, UK in the early 1990s (Macdonald *et al.* 1997) and south-west to Spain (Gortazar *et al.* 1998) and New York (Tullar *et al.* 1974). Several other diseases are also recorded, including canine distemper, parvovirus, toxoplasmosis, bovine tuberculosis, and paratuberculosis but these do not appear to be major determinants of fox density (Little *et al.* 1982; Voigt 1987; Beard *et al.* 1999).

Longevity Foxes can live up to nine years in the wild, although only an estimated one in 10,000 will do so. Foxes in agricultural Europe generally live less than three years.

Historical perspective

Red foxes are widely represented in folklore. They have been hunted since the 4th century B.C. Fox hunting with dogs has been a notable part of European culture since at least the 11th century and was spread world-wide by British colonists. Red foxes are an increasingly important component of fur harvest taken from North America. As with most other furbearers, 20th century sales numerically far exceeded those in any previous century (Obbard *et al.* 1987). In 1992–1993, red fox fur was the third most important wild-caught furbearer in North America, in terms of commercial value (Sheiff and Baker 1987). Numbers sold, and therefore presumably harvests, fluctuate heavily with demand, although in settled regions culls are also related to pest status.

Conservation status

Threats Habitat degradation, loss, fragmentation; exploitation, direct and indirect persecution; government policies. Other threats: Local, national, or international socio-economic and political factors. Increasing human population and thus increasing development.

Red foxes' versatility and eclectic diet are likely to ensure their persistence despite changes in landscape and prey base. Culling may be able to reduce numbers well below carrying capacity in large regions (Heydon and Reynolds 2000), but no known situations exist where this currently threatens species persistence on any geographical scale. There are currently bounties on subspecies *V. v. pusilla* (desert foxes) in Pakistan to protect game birds such as Houbara bustards (*Chlamydotis undulata macqueenii*), with a high hunting value.

Commercial use The number of foxes raised for fur (although much reduced since the 1900s) exceeds that of any other species, except possibly mink (*Mustela vison*) (Obbard 1987). Types farmed are particularly colour variants ("white", "silver" and "cross") that are rare in the wild.

Worldwide trade in ranched red fox pelts (mainly "silver" pelts from Finland) was 700,000 in 1988–1989 (excluding internal consumption in the USSR). Active fur trade in Britain in 1970s was negligible.

Occurrence in protected areas Present in most temperate-subarctic conservation areas with the exception of some inaccessible islands in the Old World and South America.

Protection status Widely regarded as a pest and unprotected. CITES – not listed.
V. v. necator in the Sierra Nevada, California, USA, is rare, possibly declining (Nowak 1991). The subspecies *griffithi*, *montana* and *pusilla* (=*leucopus*) are listed as CITES – Appendix III (India).

Current legal protection Most countries and/or states where trapping or hunting occurs have regulated closed versus open seasons and restrictions on methods of capture. In the European Union, Canada, and the Russian Federation, trapping methods are regulated under an agreement on international trapping standards between these countries which was signed in 1997. Other countries are signatories to ISO/DIS 10990-5.2 animal (mammal) traps which specifies standards for trap testing.

Conservation measures taken In Europe and North America, hunting traditions and/or legislation impose closed seasons on fox hunting. In the UK and a few other European countries, derogation from these provisions allows breeding season culling for pest-control purposes. Here, traditional hunting ethics encouraging restrained "use" may be at odds with harder hitting pest-control ambitions. This apparent conflict between different interest groups is particularly evident in the UK, where fox control patterns are highly regionally variable (Macdonald *et al.* 2003). In some regions, principal lowland areas where

classical mounted hunting operates, limited economic analyses suggest that the principal motive for these communal fox hunts is as a sport – the number killed is small compared with the cost of the hunting. In these regions, most anthropogenic mortality is by individual farmers shooting foxes. The mounted communal hunts do exhibit restraint – hunting takes place for a limited season, and for a prescribed number of days per week. Elsewhere, in upland regions, communal hunting by foot with guns and dogs may make economic sense, depending on the number of lambs lost to foxes (data on this is poor), and also on the current value of lost lambs. This type of fox hunting may also be perceived as a sport by its participants.

An individual deciding whether or not to control foxes, and by what means, has a complex set of factors to consider, including other interest groups, practicality and economics. For some farmers, there is evidence that a decision to control foxes may be economically perverse. Macdonald *et al*. (2003) modelled the interactions between foxes, rabbits, and rabbit-induced crop damage. For some farmers at least, a decision to kill a fox may, in some circumstances, cost that farmer a significant amount of crop loss to the rabbits that the fox and its descendants would have killed.

Occurrence in captivity
In addition to fur farms, red foxes are widely kept in small wildlife parks and zoos, but there appears to be no systematic data on their breeding success. Being extremely shy they are often poor exhibits.

Current or planned research projects
Controlling red foxes may be necessary where rare species, or threatened populations, are under threat, e.g., nest predation by foxes, has completely prevented recruitment to an internationally important sandwich tern colony in a number of consecutive years (Musgrave 1993). Attempting to control predation by lethal means can be problematic, i.e., intensive fox removal has been shown to have only local and short-term effects on predation because of swift replacement by conspecifics (Chesness *et al.*1968; Reynolds *et al.* 1993). Non-lethal methods might prove useful in managing undesirable behaviour, with some potential shown for learned food aversions for manipulating fox feeding behaviour (Macdonald and Baker 2003).

Core literature
Baker and Harris 2004; Doncaster and Macdonald 1991; Harris and Rayner 1986; Larivière and Pasitschniak-Arts 1996; Lloyd 1980; Macdonald 1977a, 1979b, 1987; Meia 1994.

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5.4 Raccoon dog
Nyctereutes procyonoides
(Gray, 1834)
Least Concern (2004)

K. Kauhala and M. Saeki

Other names
Chinese: háo/háo-zi; **Croatian:** kunopas; **Czech:** psíik mývalovitý; **Danish and Norwegian:** mårhund; **Dutch:** wasbeerhond; **Estonian:** kährikkoer; **Finnish:** supikoira; **French:** chien viverrin; **Georgian:** entiseburi dzagli; **German:** marderhund; **Hungarian:** nyestkutya; **Indonesian:** tjerpelai; **Italian:** cane procione; **Japanese:** tanuki; **Korean:** nurgoori; **Latvian:** jenotsuns; **Lithuanian:** usûrinis ðuo; **Polish:** jenot; **Portuguese:** câo-mapache; **Romanian:** câinele enot; **Russian:** enotovidnaya sobaka; **Slovakian:** psík medviedikovitý; **Slovenian:** rakunasti pes; **Spanish:** perro mapache; **Swedish:** mårdhund.

Taxonomy
Canis procyonoides Gray, 1834. Illustr. Indian Zool., 2: pl. 1. Type locality: Unknown; restricted to "vicinity of Canton, China" by Allen (1938).

The raccoon dog lineage diverged from other canids probably as early as 7–10 million years ago (Wayne 1993). Some features of the skull resemble those of South American canids, especially that of the crab-eating fox (*Cerdocyon thous*), but genetic studies have revealed that they are not close relatives (Wayne *et al*. 1997).

It has been suggested that *N. p. viverrinus* and *N. p. albus* (collectively called 'tanuki') can be separated as a different species from the other subspecies. Tanuki has fewer chromosomes than other continental subspecies with 2n=38 (Wada *et al*. 1998), while others have 2n=54 (Mäkinen 1974; Mäkinen *et al*. 1986; Ward *et al*. 1987; Wada *et al*. 1991). The chromosome number of tanuki has decreased as a result of Robertsonian translocations, which usually happens during speciation. In addition to a number of phenotypic and behavioural differences, preliminary DNA-analyses also suggest that there are considerable differences in gene frequencies between tanuki and *N. p. ussuriensis* from Finland (K. Kauhala unpubl.), and skull and tooth morphometrics also differ (Kauhala *et al*. 1998a). In addition, there are differences in the quality of fur and physiology; since the Japanese raccoon dog is adapted to mild marine climate, it has a stomach of small volume, thin fur with poor insulation properties and a poor ability to alter its body energy reserves seasonally (Korhonen *et al*. 1991).

Description
For *N. p. ussuriensis*: In autumn and winter, the raccoon dog is very fat and has thick fur, giving an expression of a round animal with short and thin legs. The black facial

Table 5.4.1. Body measurements for the raccoon dog.		
	N. p. ussuriensis **Finland** (Kauhala 1993, unpubl.).	**N. p. viverrinus** **Honshu, Japan** (Fukue 1993; Y. Fukue pers. comm.; Saeki 2001, unpubl.; S. Yachimori pers. comm.).
HB male	601mm (490–705) n=348	556mm (292–669) n=37
HB female	599mm (515–690) n=821	567mm (505–654) n=24
T male		173mm (50–230) n=37
T female		178mm (150–205) n=26
HF male		109mm (60–124) n=38
HF female		109mm (98–119) n=26
E male		44mm (20–56) n=36
E female		46mm (30–58) n=26
WT male	6.2kg (2.9–12.4) n=662	4.5kg (3.04–6.25) n=43
WT female	6.1kg (3.1–12.5) n=843	4.5kg (3.05–5.85) n=29

mask, small rounded ears and pointed muzzle are typical for the species. Hair is long on cheeks. The body colour varies from yellow to grey or reddish. There are black hairs on the back and shoulders and also dorsally on the tail. Legs, feet and chest are dark. Underhair is grey or reddish. 'Samson' raccoon dogs have no guard-hairs and underhair is reddish. The tail is rather short and covered with thick hair (Table 5.4.1). In summer when the fur is thin and fat reserves small, the animal looks much slimmer than in autumn. Dental formula is 3/3-1/1-4/4-2/3=42; m3 sometimes missing.

Subspecies There are six recognised subspecies of the raccoon dog (Ellerman and Morrison-Scott 1951; Ward and Wurster-Hill 1990):
— *N. p. albus* (Hokkaido, Japan: north of Blakiston's line at the Tsugaru straight). Body size is smaller than that of *N. p. ussuriensis*.
— *N. p. koreensis* (Korean Peninsula)
— *N. p. orestes* (south-western China)
— *N. p. procyonoides* (China and northern Indochina)
— *N. p. ussuriensis* (original range: south-eastern Russia and eastern China; introduced range: north-western parts of Russia, Finland, Sweden, the Baltic states, Belarus, Ukraine, Moldova, Poland, Germany, Hungary, Slovakia, Czech Republic, Romania, Bulgaria and Serbia, occasionally seen in Norway, Denmark, the Netherlands, France, Switzerland, Austria, Slovenia and Bosnia)
— *N. p. viverrinus* (Honshu, Shikoku and Kyushu, Japan: between Blakiston's and Miyake lines). Similar to *N. p. albus* but with somewhat shorter fur, shorter hind legs, and generally darker colour. Skull and teeth are smaller than those of *N. p. ussuriensis* (Kauhala *et al*. 1998a). Mandible width and jaw height for the skull and the lower and upper molars clearly distinguish the two subspecies.

Similar species Raccoon dogs can be confused with the raccoon (*Procyon lotor*) in Japan, Germany, France and Hungary, or the Eurasian badger (*Meles meles*), although neither are canid species. The badger has black stripes on the white head, is more strongly built and has shorter legs and tail than the raccoon dog. The tail of the raccoon is

Raccoon dog, age and sex unknown. Fukui Prefecture, Japan, 1993.

Great Tanuki Club

furry with dark bands. The badger and raccoon have five toes in each foot.

Distribution
Historical distribution In the Far East from northern Indochina to the south-east corner of Russia, also in Mongolia. In the Japanese Archipelago, the species was confined to Hokkaido, Honshu, Shikoku, Kyushu, Awaji island, Sado island and other islets of Japan except those south of Kyushu (e.g., Okinawa islands, Nansei islands, Miyako islands and Ogasawara islands). There has been a recent introduction in Yakushima island (S. Azuma pers. comm.).

Current distribution The species has been widely introduced. It is now widespread in northern and eastern Europe (Figure 5.4.1), thriving in moist forests with abundant undergrowth. The northern limit of distribution lies in areas where the mean temperature of the year is just above 0°C, the snow cover about 800mm, the duration of the snow cover 175 days and the length of the growing season 135 days (for example, in Finland the northern limit of permanent distribution is between 65°N and the Arctic Circle). If winters become milder, the raccoon dog may expand its range northwards.

Range countries (including introductions): Belarus, Bulgaria, China, Estonia, Finland, Germany, Hungary, Japan, Korea, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Serbia, Sweden (only in the county of Norrbotten), Ukraine, Vietnam. Occasionally seen in Austria, Bosnia, Denmark, France, the Netherlands, Norway, Slovenia and Switzerland (Ellerman and Morrison-Scott 1951; Mitchell-Jones *et al.* 1999).

Relative abundance
Abundance is unknown in the Far East outside of Japan where it is common. Population estimates have never been conducted in the latter country, but indirect indices (e.g., road-kills per km of the National Expressways and harvest density per prefecture), suggest that relative abundance is high in south-western parts of Japan (i.e., Kyushu, Shikoku, and Chugoku) and low in Hokkaido, Chubu, and extremely urban areas (M. Saeki and D.W. Macdonald unpubl.). See Table 5.4.2 for the status of the raccoon dog in different countries.

*Estimated populations/relative abundance and population trends*

Table 5.4.2. The status of raccoon dogs in various range countries (A=abundant; C=common; R=rare; X: present, but abundance unknown; I=increasing; S=stable).

Country	Population/abundance	Trend
Belarus	A	
Denmark	R	
Estonia	A	
Finland	45,000	S
Germany	C	
Hungary	X	I
Latvia	C	S
Lithuania	C	
Poland	C	
Russia	C	
Sweden	R	
Ukraine	X	

Habitat
Two features are typical of the habitat of raccoon dogs: 1) they are often found near water, and 2) during autumn

Figure 5.4.1. Current distribution of the raccoon dog.

Current range (native)
Current range (historical introduction)

0   1000 Km
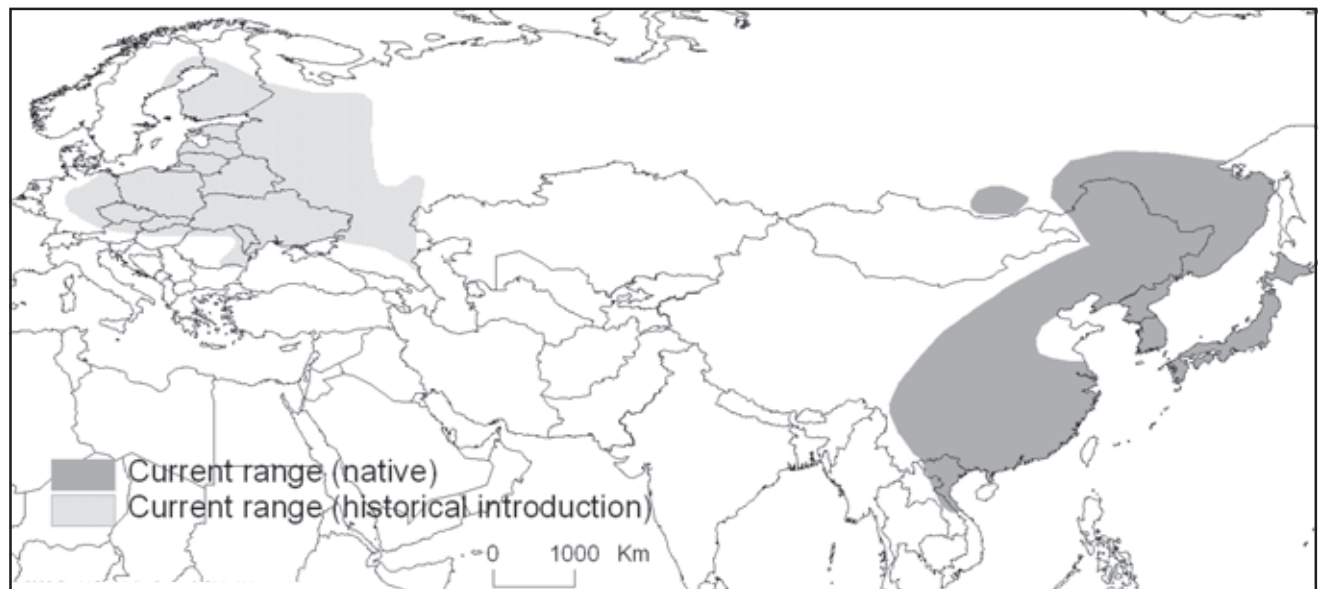
©2003 Canid Specialist Group & Global Mammal Assessment

they are more or less dependent on fruits and berries, which affects their habitat selection.

In Japan, raccoon dog habitat includes deciduous forests, broad-leaved evergreen forests, mixed forests, farmlands, and urban areas from coastal to subalpine zones. In the countryside, the species prefers herbaceous habitat and uses less *Cryptomeria* plantation throughout year, while riparian areas are often used (M. Saeki and D.W. Macdonald unpubl.). In urban areas, raccoon dogs inhabit areas with as little as 5% forest cover. In the Russian Far East, the raccoon dog favours open landscape, especially damp meadows and agricultural land and avoids dark forests (Judin 1977).

In the introduced range, raccoon dogs favour moist forests and shores of rivers and lakes, especially in early summer (Korneev 1954; Nasimovic and Isakov 1985; Kauhala 1996). In late summer and autumn raccoon dogs favour moist heaths with abundant berries (Morozov 1947; Kauhala 1996). In the Finnish archipelago, however, they favour barren pine forests where they feed on crowberries (*Empetrum nigrum*) (Kauhala and Auniola 2000).

Food and foraging behaviour

Food Raccoon dogs are true omnivores and seasonal food habits shift as food availability changes (Ivanova 1962; Kauhala *et al*. 1993a). In most areas small rodents form the bulk of their diet in all seasons (Bannikov 1964; Nasimovic and Isakov 1985). Frogs, lizards, invertebrates, insects (including adults and larvae of *Orthoptera, Coleoptera, Hemiptera, Diptera, Lepidoptera, Odonata*), birds and their eggs are also consumed, especially in early summer (Barbu 1972; Kauhala *et al*. 1993a, 1998b). Plants are frequently eaten; berries and fruits are favoured in late summer and autumn when they serve as an important food source before raccoon dogs enter winter dormancy. Oats and other agricultural products (e.g., maize/sweet corn, watermelon, loquat, tangerine, pear) are often found in raccoon dog stomachs. Carrion (e.g. ungulate carcasses), fish and crustaceans (e.g., crabs, crayfish) are consumed when available.

Foraging behaviour As opportunistic generalists, raccoon dogs forage by searching close to the ground and, in Japan, may also climb trees for fruits. They are mainly nocturnal and forage in pairs, leaving their dens 1–2 hours after sunset (Kauhala *et al*. 1993b). When they have pups, females also forage during the daytime while the male is babysitting (Kauhala *et al*. 1998c). Usually the foraging pair wanders some distance apart from each other. Raccoon dogs decrease their food intake before entering winter dormancy (Korhonen 1988).

Damage to livestock or game Waterfowl and their eggs are consumed at the seashore and the archipelago in early summer (Ivanova 1962; Naaber 1971, 1984). Fish from fish ponds may also be consumed (Saeki 2001). In the inland habitats of Finland, birds occur in the diet less often, and most of them are passerines (Kauhala *et al*. 1998b). Remains of grouse are found only occasionally in the faeces of raccoon dogs (Judin 1977). When the diets of raccoon dogs, red foxes (*Vulpes vulpes*) and badgers in early summer were compared in southern Finland, the diet of raccoon dogs was the most diverse, and raccoon dogs consumed game animals less frequently than foxes (Kauhala *et al*. 1998b).

Adaptations

Among canids, winter lethargy is a unique feature of raccoon dogs. In areas where winters are harsh, raccoon dogs spend the winter asleep; for example, in southern Finland, they start hibernation in November and become active again in March (K. Kauhala pers. obs.). Adults usually settle in the dens first (the pair together) and young later. Adult raccoon dogs almost double their weight between June and October; in June they weigh 4.5kg on average, in October 8.5kg, and sometimes 12kg (Kauhala 1993). Adults start to fatten themselves first and young when they have finished growing in late September. Autumn fattening is a consequence of decreased activity rather than increased food intake. The rate of metabolism (which is measured by thyroid activity) decreases during winter lethargy and increases again in spring. This results in weight loss which is a precisely controlled process (Korhonen 1987, 1988).

Raccoon dogs can be seen during daytime in spring, when they are sunbathing on the southern slopes of hills; they sit with their dark chest towards the sun to warm their body and save energy (Harri and Korhonen 1988).

Social behaviour

The raccoon dog is strictly monogamous, the male and female forming a permanent pair (Judin 1977; Kauhala *et al*. 1993b). Pair formation may take place before the breeding season (e.g., in September; M. Saeki pers. obs.). Pairs share their home range and also forage together. Only if one of the pair dies, will the remaining member form a new pair bond with a new mate. Some non-paired adults may stay within the same area and/or share the resting or feeding sites or dens, but, unlike pairs, non-paired adults usually do not move together. Sometimes two males move together as a pair, while in Finland, two females have not been observed together after the young have dispersed in autumn (S. Puonti pers. comm.).

Both male and female defend the home range against individuals of the same sex. The home range size varies according to the abundance of food. The core areas of different pairs are totally exclusive, especially during the breeding season. The peripheral areas of home ranges may overlap to some extent. In autumn there is more overlap than in spring and summer. Different pairs seem to avoid

each other even when their home ranges overlap to some extent (Kauhala *et al*. 1993b). Resting sites may be shared with related family members (Yachimori 1997), and latrine sites may be shared by several individuals (Ikeda 1982).

The following home range sizes have been calculated from various reported population densities: 10–20km² in the introduced range in European Russia; 7–10km² in the regions of Volga and Tatar, 4–10km² in Ukraine; 1.5km² in the Novgorod area, and 0.4–1.3km² in the Gorki area (Kozlov 1952, Morozov 1953, Popov 1956, Bannikov 1964). In Bialowieza Forest and in Suwalki Landscape Park, Poland, home ranges are 4–10km² (Jedrzejewski and Jedrzejewska 1993; Goszczynski 1999; Kowalczyk *et al*. 2000). In eastern Germany, mean home range was 3.97km² (Drygala *et al*. 2000). In Japan, home range size varies greatly, from as little as 0.07km² in an urban setting to 6.1km² in a subalpine setting (Fukue 1991, Yamamoto *et al*. 1994, respectively). According to radio-tracking studies in southern Finland, the home range size varies between 2.8 and 7.0km² (Kauhala *et al*. 1993a; K. Kauhala and K. Kiviaho unpubl.).

Raccoon dogs do not bark, but growl when menaced. In Japan, their vocalisations are higher in tone than those of a domestic dog and more or less resemble the sounds of a domestic cat. Dominant raccoon dogs can raise their tails in an inverted U-shape.

Reproduction and denning behaviour

The basic reproductive physiology of the raccoon dog is similar to that of other canids. Testosterone levels in males peak in February/March, and progesterone levels in females coincide even with absence of males, suggesting that the species is "a monoestrous, seasonal and spontaneous ovulator" (Yoshioka *et al*. 1990). Raccoon dogs achieve sexual maturity at 9–11 months and can breed in the first year, but a first-year female will enter oestrus later (>1 month) than older females (M. Saeki pers. obs.). Females can reproduce every year. Mating usually occurs in March (Helle and Kauhala 1995). This indicates the impact of climate on reproduction; the onset of spring and the length of winter lethargy determine the time of ovulation. Mating occurs in the back-to-back copulatory posture typical of other canids (Ikeda 1982).

The gestation period is nine weeks, with most parturition occurring in May (varies from April to June). The parents settle in a den about a week before the pups are born. Raccoon dogs will den in old badger sets or fox dens or they will dig dens in soft sandy soil. They will also use active badger setts, usually together with badgers (Kowalczyk *et al*. 1999). Winter dens are usually located within their home range but if suitable dens are not available, the winter den may be several kilometres outside the summer home range.

In Japan, the mean litter size (only four to five) is smaller than in other parts of the distribution area and birth weight is around 100g. However, in Finland and Poland, the mean litter size is nine and birth weight about 120g; (Helle and Kauhala 1995; Kowalczyk *et al*. 2000). Similarly, in the original distribution area in south-east Russia, the mean litter size is nine (Judin 1977). On the other hand, in north-west Russia, litter size is smaller (six to seven) because of the continental climate with harsh winters. The abundance of wild berries also affects litter size; when berries are abundant, females are in good condition the following spring, and foetal mortality rate is low and litter size is large. Furthermore, in areas where spring comes late, the young are born late and remain small and slim in late autumn, and may not reproduce the following spring. Therefore, the productivity of the population is lower in areas with long winters compared to areas with milder climates (Kauhala and Helle 1995).

Pups start emerging from the den at three to four weeks of age and are weaned at approximately four to five weeks. Both sexes exhibit parental care, taking turns to attend the den during the early nursing period (Ikeda 1983). Because the food items of raccoon dogs are small, food is not carried to the den, and the pups are fed with milk until they start to forage for themselves (Yamamoto 1984; Kauhala *et al*. 1998c). The young usually reach adult body size by the first autumn.

Competition

Potential competitors include red fox and Eurasian badger. Direct and indirect competition may take place as their diets are similar and raccoon dogs often use burrows that were dug by foxes or badgers (Yamamoto 1994). However, the degree of competition is unclear since some differences in diet do exist: the badger consumes more invertebrates and the fox consumes more mammals and birds than the raccoon dog. Furthermore, food is abundant in summer and competition between these carnivores is not likely to be severe. In winter, food is scarce but raccoon dogs and badgers hibernate and, hence, no food competition exists in winter in northern areas. In Finland, a rapid raccoon dog population increase during the 1970s and 1980s coincided with a badger population increase, suggesting that competition is not severe between these species.

In addition to these, direct and indirect competition may take place with the Japanese marten (*Martes melampus*) and with the introduced masked palm civet (*Paguma larvate*) in Japan. In Belarus, the native generalist predator populations began to decline after the raccoon dog reached a high population density; competition on carcasses in winter was proposed as a factor in the observed decline (Sidorovich 2000). Conversely, a population increase in the common raccoon in Hokkaido, Japan, may have caused a decrease in the raccoon dog population (Ikeda 1999).

Mortality and pathogens

Natural sources of mortality In Japan, stray dogs often kill raccoon dogs. Raccoon dogs, especially puppies, also fall victims to other predators such as foxes, wolves, lynxes and large predatory birds. In Japan, a masked palm civet was observed entering a raccoon dog den and possibly predated on the pups (Y. Fukue pers. obs.). Puppies may also die because of malnutrition and parasites.

Persecution They seldom are hunted for their fur (because the fur of wild raccoon dogs currently has little value), but rather because they are considered pests. In Finland, the yearly hunting bag for 2000 was 60,000–70,000 (Finnish Game and Fisheries Research Institute 2001). In Hungary, raccoon dogs have been hunted since 1997, with the yearly bag being only one to nine animals (Heltai *et al*. 2000). In Poland, raccoon dogs are hunted from August to March and the annual bag was 450–600 in the early 1990s (Biuletyn Stacji Badawczej Czempiniu 1994), but 6,200 were shot in 2002/2003 (M. Panek pers. comm.). In Sweden, the annual catch is two to seven individuals.

In Japan, legal culling has increased since the 1970s, with 4,529 annual kills on average during 1990 and 1998 (Environment Agency 1972 to 1999). However, the numbers harvested have declined. Between 18,000 and 76,000 raccoon dogs were harvested each year in Japan after World War II, declining since 1982 (although still the largest among five fur-bearer species in Japan). The scale of poaching is not known but can be substantial because people are generally unaware of the law prohibiting the capture/killing of wildlife. Furthermore, poaching is routinely overlooked in Japan. In continental Asia, little is known about the persecution level. In Finland, some raccoon dogs are killed in summer when females with puppies are protected; hunters first kill the female and then the entire litter.

Hunting and trapping for fur See Persecution and Commercial use.

Road kills Many raccoon dogs, especially young dispersing in August and September, fall victims of traffic. In Japan, conservative estimates of road kills were 110,000–370,000 per year (M. Saeki and D.W. Macdonald unpubl.).

Pathogens and parasites Raccoon dogs face a serious problem with infestation of scabies or sarcoptic mange (*Sarcoptes scabies*), which seems to be widespread in many parts of Japan and northern Europe (Wildlife Management Office, Inc. 1998; Shibata and Kawamichi 1999). Mass deaths of the infested animals can occur in winter but raccoon dogs may also recover from the disease (M. Saeki pers. obs.). Raccoon dogs are potential vectors of *Echinococcus multilocularis*, a dangerous parasite that also infects humans. Raccoon dogs can also spread trichinosis. In Belarus, raccoon dog numbers fluctuate because of helminth infections (V. Sidorovich pers. comm.).

The raccoon dog is an important vector of rabies in Europe, with increasing significance towards the east and north. In Poland, 7% of rabies cases between 1990 and 1998 have been found in raccoon dogs, 9% in Lithuania, 12% in Latvia, and 16% in Estonia (Müller 2000). During a rabies epidemic in Finland in 1988 and 1989, 77% of the cases identified were in raccoon dogs (Westerling 1991). An outbreak of canine distemper in 1991 was reported to have eliminated about 70% of the local population in western Tokyo (Machida *et al*. 1993).

Longevity Maximum life span is seven to eight years (exceptionally 10 years), with a record in captivity of 13 years. Only about 1% of raccoon dogs live to five years, and 88% of the young (in Finland) die before their first year.

Historical perspective

The raccoon dog or tanuki has often appeared in Japanese folklore (Nakamura 1990; Matsutani 1995). Tanuki used to be raised for fur and was exported mostly to the USA before World War II (Kitamura 1934).

Conservation status

Threats Road kills, persecution, government attitudes, epidemics (scabies, distemper and rabies), and pollution (organtins, lead, PCDDs, PCDFs and PCBs) remain the major threats to the species across its range.

Commercial use The Russians introduced raccoon dogs into the wild in the European part of the former Soviet Union because they wanted to establish a valuable new fur animal in the wild. Raccoon dog furs continue to be commercially sold, although today they are produced in fur farms. While the species is still commonly farmed for fur in Finland, raccoon dogs are no longer farmed in Sweden (J.-O. Helldin pers. comm.) or Hungary, where the last fur farm was closed in 1995 (M. Heltai pers. comm.). In Japan, raccoon dog fur is also used in the production of calligraphic brushes, stuffed animals, and other products.

Occurrence in protected areas Raccoon dogs occur in national parks and other wildlife protection areas in Japan, where hunting and some other activities are prohibited. Raccoon dogs occur in national parks also in Finland (although they are hunted in some parks). Elsewhere across their range, they occur in numerous protected areas and wildlife sanctuaries.

Protection status CITES – Not listed.

Current legal protection In many countries where the raccoon dog is legally hunted, hunting is permitted year

round (e.g., Sweden, Hungary and Poland). However, in Finland, females with pups are protected in May, June and July, and in Belarus hunting is allowed from 1 October to the end of February. In Japan, hunting/trapping of the species requires a licence or other form of permission and can only occur within the designated hunting season (November 15 to February 15). The raccoon dog on Mukojima island (18.4km^2), Hiroshima prefecture, is designated as a natural monument under the Law for the Protection of Cultural Properties, and permission from the Director-General of the Agency of Cultural Affairs is required for capturing the animals on the island.

Conservation measures taken There have been no conservation measures developed for the raccoon dog to date.

Occurrence in captivity
In Japan, around 40 zoos hold captive animals and successful breeding has been reported (e.g., Kobe Municipal Zoo). Captive raccoon dogs still exist on fur farms in Finland.

Current or planned research projects
In south-east Finland, K. Kauhala (Finnish Game and Fisheries Research Institute) is heading up a radio-tracking study. The aim of the study is to examine the home range size, use and overlap of raccoon dogs, red foxes and badgers, and interactions between individuals of different species in order to build a model of how rabies might be spread in the Finnish environment. Domestic cats are also included in the study.

In Japan, M. Saeki (Wildlife Conservation Research Unit, University of Oxford, UK) recently completed a study on the ecological and conservation issues of the raccoon dog, including habitat ecology, home range, movements, road kills, and agricultural damage in Japan (fieldwork in Chiba Prefecture). Ecological studies on the species and other medium-sized carnivores are continuing in the countryside.

Y. Sonoda (Meiji University, Japan) has undertaken investigations into suburban raccoon dogs in the Kanagawa Prefecture, concerning placement of protected areas for the species, habitat use, and road kills.

M. Kishimoto (Wildlife Management Office, Inc, Japan) has surveyed the distribution of latrines in order to analyse environmental factors used by the raccoon dog and to establish a large-scale survey method (in Hyogo, Tokushima and Kyoto Prefectures).

Gaps in knowledge
Although basic ecological studies on the raccoon dog have been conducted in Japan and in Finland, they were sporadic in several small study areas. There are no data available on the structure or demographic trends of the total population in Japan. Also, little is known about geographical genetic variation. In order to establish long-term conservation plans, extensive and intensive research is crucial. In addition, DNA studies to clarify the taxonomic status of the subspecies *N. p. viverrinus* and *N. p. albus* are needed.

Core literature
Ikeda 1982, 1983; Judin 1977; Kauhala 1992; Kauhala *et al*. 1998a,b,c; Saeki 2001.

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5.5 Corsac
Vulpes corsac (Linnaeus, 1768)
Least Concern (2004)

A. Poyarkov and N. Ovsyanikov

Other names
English: corsac fox; **French:** renard corsac, corsac; **German:** steppenfuchs, koraskfuchs; **Russian:** corsac; **Indigenous names:** Gobi Mongols: kirassu (Mongolia); Mongolian: kirsa, kiresa (Mongolia); Kalmic: bagata (Russian Federation); Tatarian: khorsic, corsac (Russian Federation); Kazach: karsac (Kazakhstan); Turkmenian: gorsac (Turkmenistan).

Taxonomy
Canis corsac Linnaeus, 1768:223. Type locality: "in campis magi deserti ab Jaco fluvio verus Irtim"; restricted by Ognev (1935) as " USSR, N. Kazakhstan, steppes between Ural and Irtysh rivers, near Petropavlovsk" (in Honacki *et al*. 1982).

It has been suggested that *Canis eckloni* described by Przhevalski (1883) from Northern Tibet is a subspecies of the corsac (Ellerman and Morrison-Scott 1951). However, *Canis eckloni* is in fact a junior synonym for *Vulpes ferrilata* (Geptner *et al.* 1967). This confusion probably originated from earlier work by Przhevalski referring to the latter as "corsac".

Chromosome number: 2n=36, FN=72 (Aristov and Baryshnikov 2001).

Description
The corsac is typically vulpine in appearance. Males slightly bigger than females (Table 5.5.1), but sexual dimorphism not pronounced. Head greyish-ochre or brown, ears banded brown on front side, back of ears ochre-grey or reddish-brown. Breast, belly, and groin white or slightly yellowish. Front of fore legs light yellow, rusty-yellow on sides; hind legs similarly coloured, but paler. Summer fur short and scarce; winter fur dense, soft and silky, straw-

Table 5.5.1. Body measurements for the corsac.		
	Northern Kazakhstan (Kadyrbaev and Sludskii 1981)	**Turkmenistan** (Scherbina 1995)
SK male	113mm (105–119) n=22	106mm (99–115) n=6
SK female	106mm (101–109) n=10	105mm (102–112) n=3
BL male	500mm (450–560) n=22	562mm (499–595) n=9
BL female	490mm (450–500) n=10	
T male	270mm (250–300) n=22	224mm (190–245) n=9
T female	265mm (250–300) n=10	
E male	68mm (60–75) n=22	(50–65)mm n=9
E female	68mm (60–75) n=10	
WT male	2.75kg (2.5–3.2) n=22	1.92kg (1.6–2.8) n=9
WT female	2.1kg (1.9–2.4) n=10	

greyish with ochre, brownish along the backbone line. Awn hairs tipped silver-white. Tail about half body length or slightly more, greyish-brown, covered with dense bushy hair, tipped in dark often even black. Skull similar to that of red fox (*Vulpes vulpes*), but smaller, shorter and wider, and with canine teeth more robust. The dental formula is 3/3-1/1-4/4-2/3=42.

Subspecies There is marked geographical variation. The following subspecies are defined within the former USSR (Geptner *et al.* 1967):
— *V. c. corsac* (northern part of range to PredAltai steppe, not expanding further southward than the latitude of the northern end of Aral Sea)
— *V. c. turcmenica* (plains of Middle Asia and Kazakhstan, northern Afghanistan and north-eastern Iran). There is supposedly a wide area of overlap with *V. c. kalmykorum.*
— *V. c. scorodumovi* (Russia's Transbaikalye, Mongolia and China)

— *V. c. kalmykorum* (Volgo-Ural steppes and right side of Volga basin).

Similar species Red fox (*Vulpes vulpes*): almost twice as large; lips and front of lower jaw white, back of ears darkly brown or even black; legs with dark brown or black markings; tail-tip white.

Tibetan fox (*V. ferrilata*): slightly larger; usually with two dark stripes on both sides of neck; flanks greyish, contrasting with belly; tail-tip white.

Indian fox (*V. bengalensis*): back of ears light sandy-greyish; legs uniform colour, lacking any black markings; black tail-tip.

This species may also possibly be confused with Blanford's fox (*V. cana*) and Rüeppell's fox (*V. rueppellii*), although the latter two species share little of their range. The former is noticeably smaller, with a conspicuous dark marking under the eye, and tail exceeds body length by more than half (and has dark tip); the latter is rather similar to *V. bengalensis*, but with longer tail with white tip, back of broad ears and back of head light grey, and legs without black markings.

Distribution

Historical distribution The species range was much vaster during the Quaternary. During the early Pleistocene an ancestor species *V. praecorsac* inhabited the territory of Austria and Hungary. At the end of the Pleistocene the corsac spread from Switzerland to northern China. From the end of the Pleistocene–early Holocene, the range was reduced from the west due to climate change.

Current distribution Narrower than the historical range and includes two parts. The first covers the Middle Asian republics of Turkmenistan, Uzbekistan, Tajikistan and

Corsac, age and sex not noted. Duisburg Zoo, Germany, 1995.

Chris and Tilde Stuart

Figure 5.5.1. Current distribution of the corsac.

Kazakhstan, as well as steppe and forest-steppe areas of Russia, including the southern region of Western Siberia. In Europe its range reaches the Samara Region, Tatarstan to the North and northern Caucasia to the South (Figure 5.5.1). The second, much smaller area lies in southern Transbaikalye representing the northern periphery of the Mongolian and Manchurian section of the species area. Outside Russia the species area includes the steppe part of north-eastern China, including Manchuria, Inner Mongolia, and the region between Argun and Big Khingan, the entire Mongolian republic except for its forested and mountain regions, Dgungaria, Kashgaria, Afghanistan (probably only northern) and north-eastern Iran. Southern limit of distribution is unknown, but possibly it reaches to the mountain ridges separating the Tibet Highland from the North. Thus, the two ranges (western and eastern) are connected by a relatively narrow neck in the Dgungar Gate and Zaisan Basin region. In recent years a westward area expansion has been recorded, particularly into the Voronezh region following active recovery of baibak (*Marmota bobac*) populations. Occasionally, the species is recorded from the Ukrainian steppe (as far as Pavlodar to the West), eastern Transcaucasia (Azerbaijan) and, probably, western Kyrgyzstan.

Range countries Afghanistan, Azerbaijan?, China, Iran, Kazakhstan, Kyrgyzstan?, Mongolia, Russia, Tajikistan, Turkmenistan, Ukraine?, Uzbekistan (Ognev 1931, Geptner *et al*. 1967, Scherbina 1995).

Relative abundance
In Russia the corsac is rare in most regions, but common in West Siberia and Transbaikalie. It sometimes occurs in northern parts of West Siberia's forested steppes, but in low numbers. The species is common everywhere between the Volga and Ural rivers. In Turkmenistan, Kazakhstan, Mongolia and northern China, the corsac is common or abundant, although in Tajikistan and Uzbekistan the species is usually rare. Population status in Afghanistan and Iran is unknown.

Corsac populations fluctuate significantly. Population decreases are dramatic, caused by catastrophic climatic events, and numbers can drop tenfold within the space of a single year. On the other hand, in favourable years numbers can increase by the same margin and more within a three to four year period. Dramatic population changes were reported during the last century in PredKavkazie, between Kuma and Terek rivers and in Kuma-Manich Channel region. A drastic population decline was reported at the beginning of the last century (Dinnik 1914). Numbers had recovered by 1924 to 1925; one hunter during that time could take up to 15–30 corsacs in one season (Ognev 1931). By 1931 numbers decreased again with a subsequent increase in 1951 (Verezhagin 1959). In the Ural region during particular years up to 5,500 animals were taken by trappers, and up to 1,700 in the Gurievskaya region. To the south, in Mangishlak and Ustyurt, the corsac is widespread and in some years abundant.

Estimated populations/relative abundance and population trends: The following population densities have been recorded: in Kalmykia (Russian Federation), 16–29 per 10km² (Blyznuk 1979); in Omsk region, 0.8–6.8 per 10km² during the summer period (Sidorov and Poleschuk 2002); in Kazakhstan, during population peaks, four to six animals per 10km² during the autumn-winter season (Chirkova 1952); in Eastern Transbaikalia, 1.0–6.8 per 10km², in Tuva, 3.5 per 10km², and in south-east Altai, 2.7 per 10km² (Sidorov and Botvinkin 1987).

In Turkmenistan the average population density varies in different parts of the country. In north-western and western Turkmenistan average population density is 0.4 per 10km². In the south-west corsac density is higher, and during years with high numbers of prey, such as Libyan jird (*Meriones libycus*) and great gerbil (*Rhombomys opinus*), can reach 23 per 10km². In the south-west (Karabil region) density is 8.4 per 10km² on average. In Badkhiz Nature Reserve, corsac population density during favourable years can reach very high levels, and as many as nine breeding dens per 15km² have been recorded (Sludskyi and Lazarev 1966).

Corsac population trends were studied in south-eastern Transbaikalia from 1952 to 1983 (Sidorov and Botvinkin 1987), showing populations peaking in eight general and two local populations. Peaks were repeated within a period of three to six years. Corsac fluctuations are correlated with population trends of the main prey species (Daurian pikas (*Ochotona daurica*), narrow-headed vole (*Microtus gregalis)*, and Brandt's vole (*M. branti*)). Current information on population trends in different countries is not available due to lack of centralised information on pelt harvest and research projects. However, in Orenburg (Russia) it has been estimated that there are approximately 1,500 foxes, with numbers declining (Rudi 1996). Similarly, populations are thought to be declining in Turkmenistan (Scherbina 1995) and Uzbekistan (Ishunin 1987).

During years with low prey abundance, wide migrations and animal dispersion occur. Migrations are typical for corsac populations in Western Siberia, Kazakhstan, Transbaikalia and, probably, Mongolia and China, but are not reported in Middle-Asian countries (Turkmenistan, Uzbekistan, Tajikistan, Afghanistan and Iran).

Habitat
The corsac typically inhabits steppes, semi-deserts and deserts, avoiding mountains, forested areas and dense bush. In the western part of the range they occur in low-grass steppe, avoiding dense and tall grass steppes. In Kaspyi Sea region the steppes and tarragon-cereal semi-deserts are favoured. It also occurs in fixed-sand habitats (Nogaiskaya Steppe). In Volgo-Ural watershed the corsac inhabits most usual habitats, but prefers semi-deserts. To the east of the Ural Mountains, the species inhabits steppes and in favourable years occurs even in forested steppes. In Kazakhstan typical habitats are low grass steppes and semi-deserts, often inhabiting low hills, but avoiding low mountains. In Middle-Asia it inhabits semi-deserts and ephemeral-deserts, avoiding drifting sands. One limiting factor is snow height in winter, and this species avoids areas where the depth of snow exceeds 150mm, preferring areas where the snow is either shallower or highly compressed.

Corsacs appear to depend on distribution of ground squirrels and marmots for food and shelter (the burrows being enlarged and used for refuge).

Food and foraging behaviour
Food In general, the corsac is opportunistic in its foraging habits. Prey species vary widely over the species' range, with the bulk of its diet comprising the most common small- and medium-sized rodent species in the area. Rodents and lagomorphs make up the bulk of the diet, although birds, reptiles (lizards, snakes and young tortoises) and insects are also commonly preyed upon, especially in summer. Occasionally, corsacs eat small amounts of vegetation. When the main prey species

becomes uncommon, such as during winters and periods of low prey abundance, the remains of wolf kills and carcasses of wild and domestic ungulates become a major source of food for corsacs. They will also make use of human garbage.

Typical prey in Western Siberia includes narrow-headed vole (*Microtus gregalis*) and steppe lemming (*Lagurus lagurus*), and, more rarely, red-cheeked souslik (*Cittellus erythrogenys*), water vole (*Arvicola terrestris*), great jerboa (*Allactaga major*) and skylarks (Alaudidae). During winter, small rodents, Arctic hare (*Lepus timidus*), ptarmigans (*Perdix perdix*) and snow buntings (*Pleptrophenax nivalis*) are common prey (Geptner *et al*. 1967; Sidorov and Botvinkin 1987). Some vegetable food was also found in stomachs of animals, which were captured during the winter season with abnormally high snow level (Sidorov and Polyschuk 2002).

In the forest-steppe part of Kazakhstan, the diet consists primarily of steppe lemmings and large-toothed souslik (*Ñittelus fulvus*) (Geptner *et al*. 1967). In deserts of northern Kazakhstan the proportion of prey species in corsac's diet varies, with jerboas (Dipodidae), sousliks (*Cittelus pygmaeus, C. maximus*) and rock conies (*Ochotona* spp.) dominating (Sidorov and Botvinkin 1987). On the Ustyurt Plateau and in Turkmenistan the main prey are gerbils (*Meriones* spp., *Rhombomys opimus*), while in TransBaikalie and Mongolia main species are Brandt's vole, tarbagan marmot (*Marmota sibirica*) and Daurian pika. Birds, Tolai hare (*Lepus tolai*) and long-tailed souslik (*Citellus undulatus*) are uncommon prey (Geptner *et al*. 1967).

Foraging behaviour Corsacs are active during twilight and at night. Hunting starts in the evening and continues through the first part of the night, with a second peak of activity before dawn. Sometimes they are also active during daytime, especially the young. They are solitary foragers, although near carrion or remains of wolf kills up to several corsacs may gather together (and sometimes with red foxes). Corsacs hunt by stalking prey and employing sudden short-distance attacks. Lunges on prey are very quick, faster than red fox. Corsacs find ground-nesting birds and other small prey by sound and smell. Despite their small size they can kill prey up to the size of young marmots, hares, ducks, pheasant and geese.

Damage to livestock or game Corsacs do not cause any significant damage to livestock or game.

Adaptations
Corsacs have the ability to forego water and food for extended periods of time. Although in desert regions they are often seen near springs, water pools and wells, they seem to be attracted there not by thirst, but by the abundance of rodents. In captivity corsacs do not drink water when on a protein diet, and corsacs reportedly

can live without food for 7–15 days (Kadyrbaev and Sludskii 1981).

Corsacs are well adapted to a hot and dry climate. However, according to Kalabukhov (1950), corsacs have imperfect thermoregulation, due to some of their breathing features, whereas the insulating quality of their fur is close to that of the Arctic fox. Corsacs are not resistant to strong cold, and during periods of strong frost and blizzards they do not come out from the den at all for 2–3 days. One behavioural adaptation against cold is the gathering of several animals (up to seven) in one wintering den (Sludskyi and Lazarev 1966).

Corsacs are not well adapted for walking on snow. Despite their small body-weight, their specific weight-pressure is relatively high – 68–80g/cm² in corsacs from Betpak-Dala – and their legs relatively short. By comparison, in red foxes from snowy regions this parameter is 27–30g/cm² (Geptner et al. 1967).

Social behaviour

The species' social organisation has not been studied in detail, but some general characteristics are known from studies of the species biology in the wild. The basic social unit is the breeding pair. Monogamous pairs may persist during the entire life of the partners. Even in captivity, a male corsac that was held in a cage with two females in the Moscow Zoo, copulated with only one of them, even though the second female also entered into oestrus.

Pups disperse by the end of summer. However, dispersing young do not go far from their natal range (Scherbina 1995), and some are likely to return to stay over the autumn-winter season. During winters several corsacs often are found in one den, indicating a relatively high degree of sociality. Polygynic families are probable under favourable feeding conditions; Sidorov and Botvinkin (1987) noted finding two litters and two females in one den, thus confirming occurrence of polygyny.

Home range sizes vary widely depending on region and density of foxes. In optimal habitats during favourable years of high prey abundance the home range of a family pair can be as small as 1km² (Scherbina 1995). In the Celenograd area the size of breeding territories varies from 1.9–3.7km² (Tchirkova 1952). In contrast, in low quality habitats with low food abundance, home ranges are significantly larger – in PriKaspyi Lowland, for instance, some 35–40km² (Geptner et al. 1967). There is no evidence of territoriality during winter.

Scent marking is most important for maintaining territories, and marking with urine and faeces is most frequent near maternity dens (Geptner et al. 1967). Barking is the corsacs most common vocalisation and has many different tonal variations (as detected by the human ear) and is produced in a variety of situations, such as courtship, territorial demonstrations and alarm. Barking sounds are higher than the red fox's and have a certain similarity to a cat's mew. An alarm call sounds like "Vyak". Close distance vocalisations are characterised by high-tone rhythmic sounds, peeping, chirping, and yelping.

Reproduction and denning behaviour

Across the range of the species, mating takes place from January until the beginning of March, although the actual period in any particular region is shorter. For example, in Kazakhstan and Turkmenistan, mating takes place between January and February. Gestation has been reported as 52–56 days (Geptner et al. 1967) and 60 days (Kadyrbaev and Sludskii 1981). The earliest birth time is mid-March, with most births occurring in April. Average litter size in Kalmikiya, Kazakhstan was 5.5 (range=2–10), similar to that recorded in Turkmenistan. Pups emerge from the dens from mid-May, earlier in southern parts of the species range. There is only one litter per year (Ognev 1931).

Newborn pups weigh 60–65g and measure 130–140mm in length (data from Moscow Zoo; A. Petrova pers. comm.). Pups are born blind with the auditory meatus closed. Eyes open on day 14–16. At the age of 28 days pups start eating meat. The male takes active part in parental care by feeding the young, and in favourable years helpers may join the parental pair to assist with feeding and guarding the young. Often pups play at the den during the morning. They grow rapidly, reaching the size of adults at four to five months. In captivity pups become sexually mature in nine months (Kadyrbaev and Sludskii 1981).

Corsacs develop shelters by modifying those of rodents that construct big, well-developed dens such as marmots, sousliks and great gerbils. Dens are constructed on gentle slopes or on plains. Maternity dens usually have two entrances. Near the maternity den there is a temporary shelter – dens with one entrance and a shallow corridor beneath the surface. The opening of the corridor is about 200mm in diameter. The length of the maternity den corridor varies from 1,400–4,500mm, whereas for temporary dens the corridor is from 500–1,200mm in length. The main chamber is 300 x 400mm in size, 550–1,150mm deep under ground, used for nesting but without any nesting material (Kadyrbaev and Sludskii 1981). In some areas the structure of maternity dens is more complicated. For instance, in Turkmenistan corsac dens with as many as 23 entrances have been found. Such big dens are always constructed on a great gerbil colony (Scherbina 1995). In Turkmenistan, where the climate is warmer, corsacs do not use dens during winter, whereas in colder Kazakhstan, TransBaikalie and Western Siberia, the use of dens during winter is common.

Competition

The main competitors for food within the former Soviet Union and Mongolia include red fox, steppe polecat (*Mustella eversmanii*) and grey wolf (*Canis lupus*), and, in desert regions, also steppe cat (*Felis libyca*), manul cat

(*Otocolobus manul*) and marbled polecat (*Vormella peregusna*) (Geptner *et al*. 1967). The chief competitors are red fox, which generally are better adapted and more successful hunters. In addition, red foxes compete with corsacs for dens – the stronger red fox can displace corsacs from their maternity dens and even kill them; red foxes may dig out the maternity dens of the corsac and kill litters (Geptner *et al*. 1967). When food is plentiful, corsacs and red foxes live next to each other in the same habitats and sometimes are seen feeding together on carrion. Several raptors also compete with corsacs, such as several buzzard species (*Buteo lagopus, B. rufinus, B. hemilasius*), pallid and hen harriers (*Circus macrourus, C. cyaneus*), tawny and golden eagles (*Aquilla rapax, A. chrisaetus*) and Saker falcon (*Falco cherrug*).

Mortality and pathogens

Natural sources of mortality The major mortality factor for the corsac probably is death from starvation during winter, caused by lack of availability of rodents due to deep snow-cover or decline of rodent populations. Strong frost and long periods of winter blizzards can cause significant losses in corsac populations. Predation from grey wolves during winter is also important, and wolves sometimes kill corsacs during the summer and dig out corsac dens. However, wolves play an important role for corsacs, as remains of wolf kills are an important food source for corsacs during winter. This role of wolves as food provider is more pronounced in areas of Kalmikiya, Kazakhstan, inhabited by saiga (*Saiga tatarica*). Stray and feral dogs also kill corsacs. Corsac remains were found among prey remains of tawny and golden eagles (Sidorov and Botvinkin 1987). In Semipalatinsk remains of three corsacs eaten by eagle owl (*Bubo bubo*) were reported (Geptner *et al*. 1967).

Persecution Corsacs do not fear humans, and often allow humans to approach within about 10m, before running away. They do not escape in dens from humans, unlike their reaction to wolves, dogs or eagles. When dug out of a den, corsacs sham death by lying motionless with closed eyes (Geptner *et al*. 1967).

Hunting and trapping for fur The corsac is a valuable fur-bearer species and has been trapped for a long time. For example, the following number of pelts were brought to a fur fair in Irkutsk: 1881 – 5,000; 1884 – 30,000; 1885 – 25,000; 1886 – 15,000; 1887 – 5,000; 1888 – 15,000; 1889 – 45,000; 1890 – 6,000 (Sludskyi and Lazarev 1966). In Turkmenistan, from 1924 to 1989, 103,500 corsac pelts were taken, which caused a significant decrease in corsac numbers during the same period. From 1924 to 1929, more than 4,000 animals were taken every year; from 1930 to 1939, the harvest was close to 3,000; from 1940 to 1949, the take was close to 1,000; from 1950 to 1959,

approximately 1,500; from 1960 to 1969, slightly more than 1,000; from 1970 to 1979, less than 500; and from 1980 to 1989 close to 500 (Scherbina 1995). In Uzbekistan, 1,905 pelts were taken in 1923. From 1935 to 1937, the take was 732 to 1,511 pelts every year; from 1946 to 1949 between 535 and 1,359 pelts; and from 1959 to 1967, between 1,508 and 2,739 pelts. In 1980 the harvest had fallen to only 65–100 pelts per year (Ischunin 1987). In Mongolia at the beginning of the 20th century about 15,000 corsac pelts were taken to Kalgan. In this country about 20% of pelts are used in local markets. This trend is also common for regions of Russia and countries of the former Soviet Union – a certain proportion of the total take is left for local sales. This trend became more pronounced after the break-up of the Soviet Union. Current take is unknown, although Sidorov and Poleschuk (2002) indicated that at the end of 1980s and early 1990s more than 98% of corsac skins were traded in local markets and unregistered by government officers.

Road kills Road kills are not a significant mortality factor for corsacs.

Pathogens and parasites Corsacs are susceptible to rabies (Geptner *et al*. 1967). The following helminths have been found in corsacs: *Mesocestoides lineatus, Macracanthorhynnchus catulinus* (Agapova and Sapozhenkov 1961) and *Isopoda buriatica*. In Turkmenistan several flea species were found on corsacs, among them *Pulex irritans* and *Chaetopsylla korobkovi* (Scherbina 1995). In south-eastern TransBaikalie, during a period of several years, more than 6,400 fleas were found on 195 corsacs, and representing the following species: *Pulex irritans* 70%, *Oropsylla silantiewi* 4%, *Chaetopsylla homoeus* 5%, *Ctenophyllus hirticus* 12%, and *Amphalius runatus* 3% (Geptner *et al*. 1967). The number of fleas on a fox varies over months, increasing in summer and peaking in early autumn (Brom *et al*. 1948, in Geptner *et al*. 1967)

Longevity Maximum recorded longevity is nine years (Sidorov and Botvinkin 1987).

Historical perspective
The corsac harvest is known in Kazakhstan since the Bronze Age. Kazak and Kirgiz people in the 13th century used corsac pelts almost as a means of purchasing goods. Corsacs are traditional game for hunting with aboriginal greyhounds (tazi), and with Saker falcons and golden eagle.

Conservation status
Threats Development in Kazakhstan in the mid-1850s caused a significant reduction of corsac numbers in previously undisturbed habitats. In the 20th century several catastrophic population declines were recorded. During

such crashes hunting on corsacs in the former Soviet Union was banned. For example, hunting of corsacs was stopped within the entire Kazakhstan territory from 1928 to 1938. Current population status, and the nature of major threats, is unknown in most regions. The western part of the range populations are recovering and their range expanding. In Kalmikiya large desert areas are changing into grass steppes, less suitable for corsacs. In Middle Asia and Kazakhstan a dramatic decrease of livestock during the last decade influenced many ecosystems and wildlife populations. However, the exact influence of this process on corsac populations remains unknown.

Commercial use Corsac pelts have been intensively traded. In general, over much of Russia during the 19th century, as many as 40,000–50,000 corsac pelts were traded in some years. For the time being, corsac pelts are not as highly appreciated as red fox pelts, and corsacs are usually trapped only incidentally.

Occurrence in protected areas Corsacs are protected in the following strict nature reserves (the highest protection status for the territory) (Z) and in national parks (NP):
— *China*: Chernyi Irtish (Z), Ksilingolskyi (Z), Bogdedskyi (Z), Dalainurskyi (Z);
— *Russia*: Chernie Zemli Kalmikyi (Black Soils of Kalmik) (Z), Rostovskyi (Z), Orenburgskyi (Z), Altaiskyi (Z), Ubsunurskaya Kotlovina (Z), Daurskyi (Z);
— *Kazakhstan*: Alma-Atinskyi (Z), Kurgaldzhyiskyi (Z), Naurzumskyi (Z), Barsa-Kelmes (Z), Bayanoulskyi (NP);
— *Turkmenistan*: Krasnovodskyi (Z), Repetekskyi (Z), Syunt-Khasardagskyi (Z), Kaplankirskyi (Z), Badkhiz (Z);
— *Uzbekistan*: Arnasaiskyi (Z), Karakulskyi (Z), Kizilkumskyi (Z), Nuratinskyi (Z), Chatkalskyi (Z), Uzbekskyi (NP);
— *Tadzhikistan*: Tigrovaya Balka (Z), Dashti-Djumskyi (Z);
— *Mongolia*: Oton-Tengerekskyi (Z), Nemgerekskyi (Z), Great Goby Biosphere Reserve (Z), Malyi Gobyiskyi (Z), Malyi Gobyiskyi (Z), Eastern Mongolian Mongol-Daurskyi (Z), Ubsu-Nur (Z), Khorgo (NP), Gurvan-Saikhanskyi (NP).

Protection status CITES – not listed.
Listed in some regional Red books in Russia: Bashkir (Volga tribute) and Buryat (Transbaikalia region) with category III status (species with declining populations).

Current legal protection Hunting of corsacs is regulated by special national legislation, in which the species is considered a fur-bearer species (Russia, Kazakhstan, Turkmenistan, Uzbekistan, Mongolia). Trapping/hunting is allowed only from November through March in Russia, Kazakhstan, and Turkmenistan. Certain methods of hunting are prohibited, such as digging or smoking animals out of dens, den flooding, and poisoning.

Conservation measures taken No special conservation programmes have been carried out. Outside of protected areas, the corsac has the status of game species.

Occurrence in captivity
Corsacs breed well in captivity, and there are some 29 animals currently listed in ISIS. In Moscow Zoo during 1960s one pair of corsacs produced six litters during the time that they remained together. Corsacs are easily habituated to humans.

Current or planned research projects
None known.

Gaps in knowledge
There are several aspects of this species' biology that require investigation, including social organisation and behaviour, population structure, current distribution and population status in different regions, current levels of trapping/hunting impact, and other threats to the species.

Core literature
Chirkova 1952; Sludskyi and Lazarev 1966; Geptner *et al*. 1967; Kadyrbaev and Sludskii 1981; Ognev 1931, 1935; Scherbina 1995; Sidorov and Botvinkin 1987; Sidorov and Poleschuk 2002.

Reviewer: Nikolay A. Poyarkov. **Editors:** Claudio Sillero-Zubiri, Deborah Randall, Michael Hoffmann.

5.6 Tibetan fox
Vulpes ferrilata (Hodgson, 1842)
Least Concern (2004)

G.B. Schaller and J.R Ginsberg

Other names
English: Tibetan sand fox, sand fox; **Chinese:** shahuli(li), caohu(li); **French:** renard sable du Thibet; **German:** Tibetfuchs; **Tibetan:** wa, wamo.

Taxonomy
Vulpes ferrilatus Hodgson, 1842. J. Asiatiac Soc. Bengal 11:278. Type locality: near Lhasa, Tibet.
Chromosome number 2n = 36 (Xu and Gao 1986).

Description
The Tibetan fox is small and seemingly compact with a soft, dense coat, a conspicuously narrow muzzle and a bushy tail (Table 5.6.1). It is tan to rufous-coloured on the

Table 5.6.1. Body measurements for the Tibetan fox.

	China (Feng *et al*. 1986; Gao *et al*. 1987).	South-central Tibet (G. Schaller, unpubl.).
HB male	587mm (560–650) n=7	515mm n=1
HB female	554mm (490–610) n=8	
T male	279mm (260–290) n=7	270mm n=1
T female	239mm (220–260) n=8	
HF male	131mm (125–140) n=7	140mm n=1
HF female	120mm (110–124) n=8	
E male	57mm (52–61) n=7	60mm n=7
E female	60mm (55–63) n=8	
WT male	4.1kg (3.8–4.6) n=7	3.25kg n=1
WT female	3.5kg (3.0–4.1) n=5	

George Schaller

Dead Tibetan fox, age and sex unknown, held by hunter.

muzzle, crown, neck, back, and lower legs. The cheeks, sides, upper legs and rump are grey; the tail is also grey except for a white tip. The back of the relatively short ears is tan to greyish-tan and the inside is white. The undersides are whitish to light grey.

Subspecies No subspecies have been described.

Similar species The corsac (*Vulpes corsac*) is similar in size, but has relatively longer legs and conspicuously large ears. Its pelage is reddish grey with white underparts.

Current distribution
Widespread in the steppes and semi-deserts of the Tibetan Plateau from the Ladakh area of India, east across China including parts of the Xinjiang, Gansu, Qinghai, and Sichuan provinces and all of the Tibet Autonomous Region. Also present in Nepal north of the Himalaya, known specifically from the Mustang area (Figure 5.6.1).

Range countries China, India, Nepal (Schaller 1998; Nowak 1999).

Relative abundance
In general, fox density appears to be low. Its abundance depends partly on prey availability and partly on human
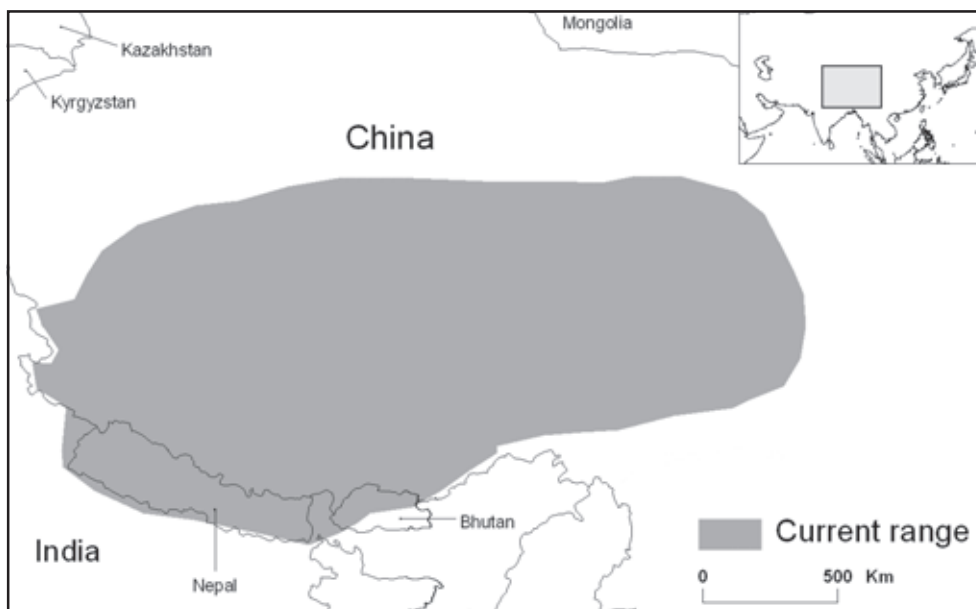

Figure 5.6.1. Current distribution of the Tibetan fox.

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hunting pressure. In north-west Tibet, in a remote region of desert steppe with little prey, only five foxes were seen in 1,848km of driving. In south-west Qinghai in a benign environment with much prey, 15 foxes were tallied in 367km (Schaller 1998). In Serxu county, north-west Sichuan Province, an area with abundant with black lipped pika (*Ochotona curzoniae*) eight Tibetan foxes were sighted along 11km country road during a night count in 2001 (Anon., 2000b), and 27 sightings (at least 12 individuals) were recorded along line transects in the same area in August 2003 (Wang Xiaoming and Wang Zhenghuan, pers. obs.).

Estimated populations/relative abundance and population trends A survey of 43 counties of Tibet's autonomous region estimated around 37,000 Tibetan foxes (Piao 1989).

Habitat
The species is found in upland plains and hills from about 2,500–5,200m a.s.l. Much of its habitat consists of alpine meadow, alpine steppe, and desert steppe, all treeless vegetation types. The climate is harsh with temperatures reaching 30°C in summer and dropping to -40°C in winter. Most of the fox's range lies in semi-arid to arid environments with average annual precipitation of 100–500mm, most of it falling in summer.

Food and foraging behaviour
Food The principal diet of the Tibetan fox consists of pikas (*Ochotona* spp.) and rodents. An analysis of 113 droppings from north-west Tibet revealed a content of 95% pika (*O. curzoniae*) and small rodents (*Pitymus*, *Alticola*, *Cricetelus*). Another 2.7% was Tibetan antelope (*Pantholops hodgsoni*) probably scavenged, and the remainder insects, feathers, and vegetation, including *Ephedra* berries (Schaller 1998). Feng *et al.* (1986) also list Tibetan woolly hare (*Lepus oiostolus*) and a lizard species (*Phrynocephalus* sp.) as prey items, and Zheng (1985) further noted the remains of marmot (*Marmota himalayana*), musk deer (*Moschus* sp.), blue sheep (*Pseudois nayaur*) and livestock in 58 droppings collected in eastern Qinghai Province.

Foraging behaviour Since pikas are diurnal, foxes often hunt in daytime, trotting through or stalking in pika colonies. Of 90 foxes observed, all but six pairs were solitary, suggesting that they mainly hunt alone (G. Schaller pers. obs.).

Damage to livestock or game No quantitative data are available other than occurrence of livestock in diet.

Adaptations
Little is known about this generic small fox.

Social behaviour
Tibetan foxes have never been studied and all aspects of their reproductive and social behaviour remain unknown. As noted, they are usually seen alone or in pairs consisting of a male and female, although one family was observed in 2001, comprised by three adults and two juveniles (Wu Wei *et al.* 2002). Burrows are found at the base of boulders, along old beach lines, low on slopes, and other such sites. There may be one to four entrances to a den, the entrance about 25–35cm in diameter (Schaller 1998).

Reproduction and denning behaviour
Nowak (1999) suggests mating occurs in February with 2–5 young born in May, but the source of these data is not given. Wang Zhenghuan *et al.* (2003a) studied the main habitat factors associated to the location of summer dens in 2001 (n=54 den holes); these were, in order of importance: water distance, slope degree, position along the slope, small mammal den numbers, and vegetation type. Most dens were located in grasslands (96.3%) with moderate slope (68.52% between 5–25°).

Competition
The geographic ranges of red fox (*Vulpes vulpes*) and Tibetan fox overlap, though the former favours mountains, including forested ones, and the latter open steppes. The two species have a similar diet. Indeed, pikas, the principal prey in their region of overlap, are also a staple of brown bear (*Ursus arctos*), polecat (*Mustela eversmannii*), manul (*Felis manul*) and various raptors, as well as on occasion the grey wolf (*Canis lupus*).

Mortality and pathogens
Natural sources of mortality Unknown.

Pathogens The infection rate of *Echinococcus* spp. in Tibetan foxes in Serxu county Sichuan province is high, estimated by Qiu *et al.* (1995) at 59.1%. Recent evidence from western Sichuan, China, indicates that Tibetan foxes are definitive hosts of Alveolar Hydatid Disease (AHD), a rare but serious zoonosis caused by *Echinococcus* spp. (Wang *et al.* 2003b).

Hunting and trapping for fur The Tibetan sand fox is hunted for its pelt, which is made into hats, but red fox is preferred as such adornment. Feng *et al.* (1986) reported of high hunting pressures in the whole Tibetan plateau since the 1960s and the Tibetan fox population in Serxu is under heavy human hunting pressure (Wang Zhenghuan *et al.,* 2003a). Over 300 foxes have been killed per year since the 1990s in Shiqu County, Sichuan Province, China (Wang Xiaoming, unpubl.). Hunting methods include shooting and traps laid at the entrance of den holes, the latter been the main method as guns in the area have been restricted in the recent years.

Road kills No data available.

Longevity Unknown.

Historical perspective
The fox is used to make hats by local people. No explicit conservation measures undertaken to date.

Conservation status
Threats Unknown, but the species is not under threat.

Commercial use No data available.

Occurrence in protected areas Present in the Arjin Shan (45,000km²), Xianza (40,000km²), Chang Tang (*c.*334,000km²), and Hoh Xil (*c*.45,000km²). Likely to occur in other protected areas throughout the species' range, but no reliable information available.

Protection status CITES – not listed.

Current legal protection Species legally protected in several large Chinese reserves (see above), but actual protection remains minimal. The species lacks special protection outside reserves.

Conservation measures taken No information available, although it is unlikely that any proactive measures have been taken by any of the range countries.

Specific actions being undertaken or completed None.

Occurrence in captivity
No records in Western zoos; occurrence in Chinese and Russian zoos unknown.

Current or planned research projects
Recently Wang Xiaoming (East China Normal University, Shanghai, China) began a study of the species in Sichuan.

Gaps of knowledge All aspects of the fox's natural history need study.

Core literature
Piao 1989; Schaller 1998; Wang Zhenghuan *et al*. 2003a; Zheng 1985.

Reviewers: Andrew T. Smith, Wang Xiaoming. **Editor:** Claudio Sillero-Zubiri.