Chapter 5

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).

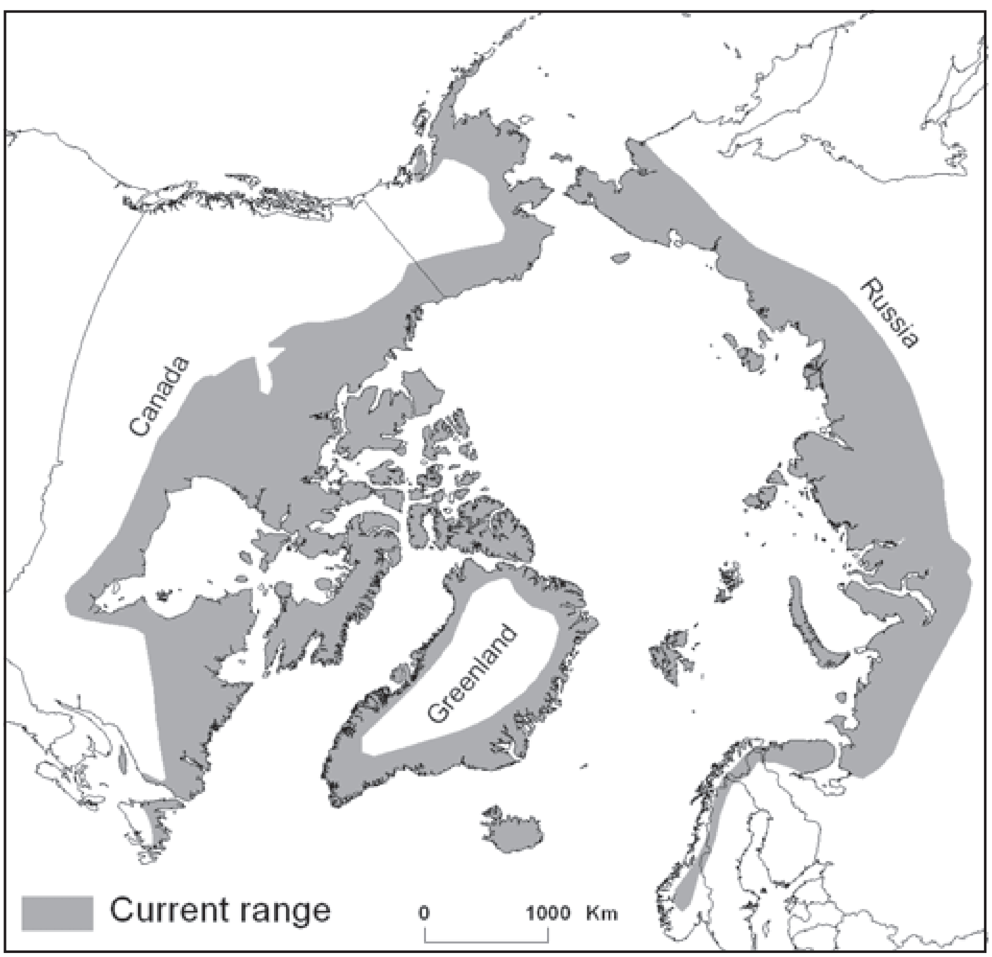

Figure 5.1.1. Current distribution of the Arctic fox.

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 jänka, 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.

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