



Management of the arctic fox (*Vulpes lagopus*): Implementation of international and national obligations in Iceland and Svalbard

Matthias Kühn



**Faculty of Life and
Environmental Sciences
University of Iceland**

Management of the arctic fox (*Vulpes lagopus*): Implementation of international and national obligations in Iceland and Svalbard

Matthias Kühn

60 ECTS thesis submitted in partial fulfillment of a
Magister Scientiarum degree in Environment and Natural Resources

Advisor(s)
Mariana Tamayo
Ester Rut Unnsteinsdóttir

Faculty of Life and Environmental Sciences
Environment and Natural Resources
University of Iceland
Reykjavík, September 2015

Management of the arctic fox (*Vulpes lagopus*): Implementation of international and national obligations in Iceland and Svalbard
Arctic fox management in Iceland and Svalbard
60 ECTS thesis submitted in partial fulfillment of a *Magister Scientiarum* degree in Environment and Natural Resources

Copyright © 2015 Matthias Kühn
All rights reserved

Faculty of Life and Environmental Sciences
Environment and Natural Resources
University of Iceland
Sturlugata 7
IS-101 Reykjavík
Iceland

Telephone: 525 4000

Bibliographic information:

Kühn, M., 2015, *Management of the arctic fox (Vulpes lagopus): Implementation of international and national obligations in Iceland and Svalbard*, Master's thesis, Faculty of Life and Environmental Sciences, University of Iceland, pp. xii + 48.

Printing: Háskólaprent
Reykjavík, Iceland, September 2015

Abstract

The arctic fox (*Vulpes lagopus*) is Iceland's only native terrestrial mammal and an important species in Icelandic ecosystems. However, this species has long been regarded as a vermin in Iceland. Major changes in Iceland's environmental policies in the 1990s awarded, for the first time, a protection status to the arctic fox. Svalbard's arctic fox population is considered viable and stable and the species, one of the few top predators in the arctic, is equally important to Svalbard's ecosystems. The species gained the status of a priority species in Svalbard in the 1990s and is regarded as one of the main indicators for the state of the environment in Svalbard. This study reviews the historical background of arctic fox hunting in Iceland and Svalbard, and focuses on the development of the current management regimes for the species. Further, it examines the effect of international commitments on national legislations and management of arctic foxes in Iceland and Svalbard, and provides recommendations to further protect this species. The study shows that the implementation process of international obligations into national legislations in Iceland and Svalbard has ushered major changes in the protection of the arctic fox. Further, the comparison of Iceland and Svalbard represents a good example to develop management strategies for other arctic islands with arctic fox populations to promote the overall long-term survival of the species on a global scale. This study provides comprehensive legislative and management recommendations to complement Iceland's enormous transformation and achievements towards protecting its arctic fox population. Iceland serves as an example of a sea ice free arctic fox population and can, hence, contribute to potential management strategies on other arctic islands that will become free of sea ice in the future due to climate change.

Den höchsten Frieden findet der, der schützt, was atmet, schützt, was lebt. (Buddha)

Table of Contents

List of Tables	ix
Acknowledgements	xi
1 Management of the arctic fox in Svalbard	1
1.1 Introduction.....	1
1.2 Historical Overview	3
1.2.1 The early history of Svalbard from 1596 to 1700.....	3
1.2.2 Russian overwintering trapping from 1700 to 1852	3
1.2.3 Norwegian overwintering trapping from 1795 to 1941	4
1.3 The Svalbard Treaty of 1920 and the Svalbard Act of 1925	6
1.4 Environmental protection in the 1970s.....	8
1.5 Svalbard’s Environmental Protection Act and the <i>status quo</i>	9
1.6 Conclusion	12
1.7 References.....	14
2 Management of the arctic fox in Iceland	19
2.1 Introduction.....	19
2.2 Historical Overview	21
2.2.1 Management of the arctic fox from 930 to 1994	21
2.2.2 The new legislations of 1994 and the Nature Conservation Act	24
2.3 International obligations	27
2.4 Planned improvements of current legislations.....	29
2.5 Conclusion	30
2.6 References.....	32
3 Comparison of arctic fox management in Iceland and Svalbard	37
3.1 Introduction.....	37
3.2 Arctic fox management in Iceland and Svalbard.....	38
3.3 Regulatory and legislative recommendations	40
3.4 Management recommendations	41
3.4.1 Examination of damage to livestock.....	41
3.4.2 Metapopulation/Migration studies.....	43
3.4.3 Emerald Network	43
3.4.4 Minimum viable population (MVP)	44
3.5 Conclusion	44
3.6 References.....	46

List of Tables

Table 1.1 Summary of the number of hunted arctic foxes in Svalbard from 1596 to 1971	7
Table 1.2 National and international legislative changes regarding environmental protection in Svalbard from 1925 to the present	11
Table 2.1 Legislation changes from 930 to 2013 regarding the management of arctic foxes in Iceland.....	28

Acknowledgements

Many great things have come along my way while preparing this thesis. Without the kind support of many individuals it would not have been such a meaningful and important time for me. I would like to extend a sincere thank you to all of them.

First of all, I would like to thank the University of Iceland (Háskóli Íslands) in Reykjavík for giving me the opportunity to join the interdisciplinary Master's program 'Environment and Natural Resources (M.Sc./M.A.)'. The two years in Iceland truly changed my life and inspired me greatly to follow my inner visions to make a difference in our world. Further, I like to take the opportunity to express my gratitude to my supervisors Mariana Lucía Tamayo (University of Iceland) and Ester Rut Unnsteinsdóttir (Icelandic Institute of Natural History) for their guidance and support throughout the whole two years of my Master's studies in Iceland. Besides my supervisors, I would also like to thank Kristinn Haukur Skarphæðinnsson (Icelandic Institute of Natural History) for being a supportive opponent and for his final ideas of improving the thesis.

A special thanks goes to Trausti Baldursson from the Icelandic Institute of Natural History for pointing out where to find valuable information about the status of Iceland's legislations. I would also like to show my gratitude to Eva Fuglei (Norwegian Polar Institute) and Bjarte Benberg (Governor of Svalbard) for providing me with data and comprehensive information for my thesis.

Further, I am very grateful to Sandra Lai (Université du Québec) for her invaluable advice and continuous support throughout the last two years. I also take this opportunity to express my gratitude to Ragnheiður Erla Björnsdóttir (Iceland Academy of the Arts) for her translations of Icelandic texts and legislations, which marked the very beginning of my thesis work.

At last, I would like to extend my heartfelt gratitude to Lora Elín Einarsdóttir, who supported me unconditionally throughout the last summer and whose support gave me the strength and confidence I needed to finish my Master's degree here in Iceland. It has been a long and life-changing journey that has found its beginning here in Iceland and has just to be continued. Thank you for being part of it!

1 Management of the arctic fox in Svalbard

1.1 Introduction

The arctic fox (*Vulpes lagopus*), one of two native terrestrial mammals that inhabit the archipelago of Svalbard year round, is the most common fox species living in the Arctic (Audet et al., 2002). It thrives in cold climates, in all tundra habitats in the polar region (Angerbjörn and Tannerfeldt, 2014) and is the only mammalian predator endemic to the Arctic territories (Ims et al., 2013). Given its circumpolar distribution, the arctic fox has been selected as a flagship species by the International Union for Conservation of Nature (IUCN) to represent climate change and its consequences on the Arctic tundra, including habitat loss, increased red fox (*V. vulpes*) competition, and changes in prey abundance (IUCN, 2009a, 2009b). After a drastic decline of the arctic fox population in Fennoscandia due to continuous hunting pressure, the species received full protection in Sweden, Norway, and Finland in 1928, 1930 and 1940, respectively (Angerbjörn et al., 2004). Despite this protection status for more than 70 years, the arctic fox population in Fennoscandia has failed to recover significantly from its collapse in the 1920s (Dalén et al., 2002; Hersteinsson et al., 1989). Consequently, the arctic fox is classified by Sweden's National Red List for Species as 'Endangered' (Swedish Species Information Centre, 2015), whereas Norway and Finland list the species as 'Critically Endangered' (Finnish Ministry of the Environment, 2010; Norwegian Biodiversity Information Centre, 2010a). Additionally, the arctic fox is given full protection in Europe since it is considered a priority species with a need for strict protection under Annex II and IV of the European Union (EU) Habitats Directive 92/43/EEC (Council of Europe, 2007). However, the arctic fox is not threatened in most of its range and is classified as a species of 'Least Concern' by the IUCN's Red List of Threatened Species (2014). For example, Svalbard's arctic fox population is believed to be viable and stable (Fuglei et al., 1998; Ims et al., 2014; Sander et al., 2006) and is classified as 'Least Concern' by the Norwegian Red List for Species (Norwegian Biodiversity Information Centre, 2010b). Nonetheless, it is seen as an important species of Svalbard's ecosystem and in the 1990s was given the status of priority species (Fuglei et al., 1998).

The overall health of arctic foxes is regarded as an indication for the state of Arctic ecosystems (IUCN, 2009a). The arctic fox is one of the few top predators in the polar regions, underlining its importance in maintaining the fragile balance of highly codependent Arctic communities (Gilg et al., 2009). Current research predicts that future climatic changes will have significant effects on Arctic ecosystems (ACIA, 2004) and, subsequently, on the distribution and abundance of arctic foxes (Callaghan et al., 2004; Fuglei and Ims, 2008; IUCN, 2009a, 2009b). Although Arctic islands are vulnerable to afforestation due to increased temperatures and the positive response of woody plants (Walker et al., 2006), island populations of arctic foxes are hypothesized to be more resilient towards climate change because islands are less susceptible to the northward

expansion of the boreal forest, thus reducing an additional threat to the Arctic tundra habitat (IUCN, 2009b). Furthermore, the continued warming of the Arctic will limit the movement of species via sea ice, likely reducing the risk of invasion of competitor species such as the red fox to Arctic islands (Fuglei and Ims, 2008). Given this potential of greater resilience to climate change of island populations, it is imperative for the long-term survival of arctic foxes that island populations be safeguarded (Fuglei and Ims, 2008).

Comprehensive management of the arctic fox, based on up-to-date knowledge, is essential to ensure proactive conservation efforts and avoid reactive conservation actions that are often more costly. Arctic fox populations on islands often have lower genetic diversity (Frankham, 1997), likely limiting their recovery potential after a bottle-neck event (IUCN, 2009b). For example, the recovery of the arctic fox population in Iceland, after a drastic decline of the population in the 1960s and early 1970s to only 1,000-1,300 individuals (Angerbjörn et al., 2004; Hersteinsson, 2006), indicates that this population's current genetic diversity is comparable to that of the severely endangered population in Fennoscandia (Norén et al., 2009). Such low genetic diversity is of great concern because it increases the risk of lower fitness and it can reduce the effectiveness of conservation actions as seen in Fennoscandia and its critically endangered arctic fox population (Hersteinsson et al., 1989). Hence, a comprehensive management system targeting arctic fox populations on Arctic islands is needed to prevent the loss of genetic diversity and reduce the risk of extinction.

Svalbard's thriving arctic fox population represents a good example to look at an existing management system that aims to both foster research and maintain the hunting tradition of the archipelago. Hence, it provides valuable knowledge and guidelines to help develop management plans for arctic fox populations in other Arctic regions. Besides several international agreements such as the Convention on Biological Diversity (CBD) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Norway stipulated national legislations with the ambitious goal to develop Svalbard as one of the best managed wilderness areas of the world. Furthermore, the Norwegian government raised the importance of the arctic fox as a priority species for the whole nation with its Royal Decree of 2015 in accordance to its new Nature Diversity Act (2009) (Ministry of Climate and Environment, 2015). Despite the prioritization of the arctic fox, there are data gaps regarding the species in Svalbard. For example, there are no quantitative estimates available for the number of arctic foxes present in Svalbard (Norwegian Polar Institute, 2015). Also it is unclear what the public health risks are regarding rabies from the interaction of humans and arctic foxes. With its first reported outbreak in 1980 and the newest one in 2011, the arctic fox is referred to as the main vector in bringing the virus to Svalbard (Mørk et al., 2011) and transmitting it to other species like the Svalbard reindeer (*Rangifer tarandus platyrhynchus*) (MacDonald et al., 2011). Furthermore, there is a need of an historical overview of arctic fox hunting and management in Svalbard to help achieve the goal of one of the best managed wilderness area in the world.

The purpose of this study is to provide a comprehensive review of the historical background of arctic fox hunting in Svalbard as well as an insight into the development of the present arctic fox management on the archipelago. Specifically by reviewing existing literature and legislations, the study aims to identify (1) how international and national obligations are reflected in the current arctic fox management in Svalbard, (2) how the actual management efforts account for Norway's ambitious environmental policies for

Svalbard, and (3) if the management is in line with international efforts to preserve the species on a long-term scale. Furthermore, additional management actions will be recommended for the arctic fox populations on Svalbard highlighting the importance of the species for both the archipelago and the Arctic.

1.2 Historical Overview

The extraordinary fur of the arctic fox, which is known to be the best insulating fur of all mammals (Scholander et al., 1950), made the species one of the most valuable hunted mammals in all of its range for centuries. The exact date when the hunting of arctic foxes began in Svalbard is unknown because the archipelago had long been without permanent settlements. Nonetheless, the early exploration of the Svalbard archipelago can be traced to the middle of the second millennium. The archipelago was first mentioned in Icelandic and Norwegian chronicles in the 12th century, which described Svalbard's islands as 'cold or barren coasts' (Nuttall, 2012). However, it can only be conclusively confirmed through historical data that Willem Barentsz and his Dutch expedition reached Svalbard for the first time in 1596 (Lønø, 1972; Nuttall, 2012). The discovery of Svalbard by Willem Barentz marks the starting point of over 400 years of non-indigenous exploration of the archipelago (UNESCO, 2007). The following subsections will discuss the development of arctic fox hunting in Svalbard from the beginning of the European exploration of the archipelago in order to understand the background of today's arctic fox management in Svalbard.

1.2.1 The early history of Svalbard from 1596 to 1700

Shortly after Barentsz' expedition in 1596 several European shipping nations (e.g. England and the Netherlands) headed north to exploit the rich natural resources of Svalbard's coastal waters, which included whales, seals and walrus (Johansen et al., 2011; Nuttall, 2012; Umbreit and Edmunds, 2009). The beginning of the 17th century (1612) marks the first time when organized whale hunting occurs off the coast of Svalbard (Johansen et al., 2011). The European coastal whaling industry in Svalbard reached its peak hunting from 1630-1635 (Johansen et al., 2011) and continued throughout the 17th century. Eventually, however, whaling shifted from coastal to open sea hunting in the middle of the 17th century due to a decline in whale populations in coastal areas (Johansen et al., 2011; Nuttall, 2012). Estimates indicate that by the end of the 17th century around 200-300 whale and seal ships were present during the summer. This European dominance changed at the beginning of the 18th century when Russians traders (the Pomors) became key players in Svalbard (Nuttall, 2012). European overwintering occurred in Svalbard during the 17th century (Umbreit and Edmunds, 2009), but it is unclear if it was systematic or unplanned (Nuttall, 2012). Based on available historical data from this period, the hunting of arctic foxes seems to have played no role (or only a minor one) during this early exploitation of Svalbard's natural resources.

1.2.2 Russian overwintering trapping from 1700 to 1852

The first significant utilization of Svalbard's terrestrial resources can be traced back to the beginning of the 18th century, when the Pomors ('Sea people') permanently established overwintering stations on the archipelago (Johansen et al., 2011; Nuttall, 2012). In contrast to the European hunt for marine resources, they focused merely on hunting land-dwelling

fauna because of their tradition-based expertise in hunting terrestrial animals (Umbreit and Edmunds, 2009). The purpose of overwintering in Svalbard originated solely from hunting valuable goods such as pelts and down (Avango et al., 2011; Johansen et al., 2011). The Pomors' hunting concentrated on walrus (*Odobenus rosmarus*), seals (e.g., *Pusa hispida*, *Erignathus barbatus*, *Phoca vitulina*), Svalbard reindeers, common eiders (*Somateria mollissima*), numerous bird species, polar bears (*Ursus maritimus*) and arctic foxes (Johansen et al., 2011; Nuttall, 2012; Umbreit and Edmunds, 2009). In addition to hunting saleable goods, the Pomors also hunted for subsistence (Johansen et al., 2011; Umbreit and Edmunds, 2009). The overwintering of the Russians, primarily from 1720-1839, represents the first long-term settlement in Svalbard's harsh environment, which began with the establishment of year round trapping stations (Johansen et al., 2011; Nuttall, 2012; Umbreit and Edmunds, 2009). At the beginning these stations were small cabins that with time developed into larger stations with several buildings (Avango et al., 2011; Johansen et al., 2011). In the early 19th century, the decline in pelt prices, wars on mainland Europe and the overexploitation of the walrus population in 1830 led to a reduction in hunting activities in Svalbard, ending eventually the era of the Pomors in 1852-1853 (Johansen et al., 2011; Lønø, 1972). During this period of 150 years, the Russians were the only ones inhabiting Svalbard year round (Umbreit and Edmunds, 2009). It is not known to what extent these hunting efforts impacted the fauna in Svalbard since there are no historical records available. But it is likely that the arctic fox population faced a certain amount of hunting pressure since its fur was one of the most valuable terrestrial resources for both trading and subsistence.

1.2.3 Norwegian overwintering trapping from 1795 to 1941

The first systematic overwintering by Norwegians in Svalbard was in the winter of 1795-1796 (Lønø, 1972; Vylegzhanin and Zilanov, 2007), which, as the Russian's, was for harvesting natural resources (Johansen et al., 2011). Other literature mentions 1778 as the first time when Norwegian hunters attempted to overwinter in Svalbard (Umbreit and Edmunds, 2009). However, during the following 100 years the Norwegian exploitation of Svalbard's terrestrial resources was intermittent, and overwintering only occurred because of severe weather conditions that forced summer hunting parties to remain in Svalbard. Up until 1892 the Norwegians had overwintered in Svalbard 21 times, but only 14 of these were planned, the others were accidental (Johansen et al., 2011). During this period the Norwegian hunting efforts were mainly based on ships focusing on maritime species like walrus, seals and polar bears (Umbreit and Edmunds, 2009). Nonetheless, it is documented that these hunters also trapped arctic foxes during these few overwintering seasons (Lønø, 1972) (Table 2.1). For instance, 30 arctic foxes, 677 walrus and 3 polar bears were hunted in the winter season of 1824-1825 (Lønø, 1972). As the numbers show, the hunting was mainly on the walrus and its valuable ivory. Similarly, the largest hunt of walrus (750 individuals taken) occurred the previous winter (1823-24) with only 9 hunters (Lønø, 1972). The decline of Svalbard's walrus population in 1830, caused the Norwegian hunting season to move primarily to the summer, but it still focused on hunting walrus. This hunting emphasis on walrus continued until 1870 (Lønø, 1972). The hunters' diaries from this period, collected and interpreted by Lønø (1972), show that there were relatively few foxes hunted. The occasional record of hunted arctic foxes ranged from 4 foxes (winter 1888-89) to 30 foxes (winters of 1923-25 and 1965-66) (Fuglei, 2015; Lønø, 1972). The main reasons for such low hunting numbers were illnesses to hunters such as scurvy, and the adverse conditions during the long polar nights in Svalbard, which were often

unfavourable for hunting (Lønø, 1972). Furthermore, the diaries' from this period deal primarily with the tragedy and heroism of the people living through the long cold winters in Svalbard. Hence, it is likely that not all hunted species were recorded in these diaries. Despite this, it can be assumed that during this period hunting had a minor effect on the arctic fox population in Svalbard.

From 1892 and onwards the Norwegians were overwintering continuously in Svalbard (Brown, 1919; Johansen et al., 2011; Umbreit and Edmunds, 2009). The number of hunting records in Svalbard increased around 1895. Rossnes (1993), however, considers these records up until 1925 as poorly documented and lacking adequate data. Nonetheless, these records provide valuable information about the extent of hunting terrestrial species in Svalbard. For example, they show that hunting mainly focused on the southern, western and eastern parts of the archipelago until 1910 (Johansen et al., 2011). The establishment of the mining industry in Svalbard in 1905 changed the overwintering in Svalbard, as permanent settlements were founded, allowing hunting parties to use coal ships to transport people and equipment (Rossnes, 1993). After 1910, hunting expanded to the entire archipelago including its northern territories. From 1895-1941, a total of 41 winter seasons were registered, and an average of 25 hunters overwintered annually in Svalbard with the highest number (63 hunters) recorded 1908-09 (Rossnes, 1993). The whole harvesting business decreased sharply before and during the First World War, but rebounded again to about 25 hunters overwintering in the 1920s. The 1930s mark the most stable hunting activity of around 25-35 hunters per year (Rossnes, 1993). The outbreak of the Second World War resulted in a sudden decline in the number of hunters on the archipelago, ending the Norwegian overwintering era. In the autumn of 1941, the last remaining 16 hunters, together with the population of the main settlement in Svalbard, Longyearbyen, were evacuated to mainland Europe (Nuttall, 2012; Rossnes, 1993).

Regarding the harvesting of valuable furs, the hunting parties divided the various regions of Svalbard into polar bear and arctic fox hunting areas from 1895-1941. This was possible because of Svalbard's natural conditions, which allowed a distinction based on where the different species were mostly likely to occur (Rossnes, 1993). Furthermore, the hunting parties divided the hunting seasons according to the time of year when the fur of these species are of higher quality (Johansen et al., 2011). Therefore, the hunting of arctic foxes took place from late October to the beginning of April, while polar bears were only sought after from the beginning of February to the beginning of April (Rossnes, 1993). It should be noted that the hunting focus depended mostly on the ever changing market conditions. The products with the best prices and easiest provision helped determine hunting in the winter season (Rossnes, 1993). Hence, the hunting periods were coordinated between the resources to obtain the highest financial outcome. Since the harvest was primarily based on economic value, recording the number of hunted species was not a main priority. Consequently, the documentation from this time period concentrates on the economic output rather than the total number of harvested animals. Nonetheless, available data give an insight into the magnitude of hunting on the arctic fox population in Svalbard. It shows that the number of trapped arctic foxes fluctuated during 1892-1905, ranging from 3 foxes in 1895-96 to 239 foxes in 1900-01 (Fuglei, 2015).

A change can be seen after 1905, when mining was established in Svalbard and it helped stabilize the hunting numbers of arctic foxes, ranging from 220 (1909-10) to 534 individuals (1908-09) (Fuglei, 2015, unpubl. data). The hunting efforts during this period resulted in a decline in all hunted animal populations, causing the hunters to

supplement their hunting with poisoned bait (Brown, 1919). This method was very effective and allowed hunters to keep their hunting numbers up temporarily to compensate for the diminishing populations. However, this short-term success led to the extinction of arctic foxes and Svalbard reindeers on the west coast of Svalbard (Brown, 1919).

The First World War caused a sharp decline in hunting efforts. On average there were only 1-2 overwintering hunting parties from 1914-18, even though fur prices increased (Rossnes, 1993). Historical data indicate that 383 arctic foxes were trapped during these years (Fuglei, 2015, unpubl. data). The end of the war heralds a new era of arctic fox hunting in Svalbard that generated a continuous hunting pressure during the next two decades. From 1919-25 the numbers of harvested arctic foxes ranged from ca. 200-350 per season (Fuglei, 2015). Up until 1925 it was customary to hunt all wildlife that was available, and hunters often used carcasses from hunted animals, usually seabirds, as bait for arctic fox traps, which was called 'feed the terrain' (mate terrenget) (Rossnes, 1993). The second half of the 1920s brought the first hunting regulations in Svalbard. These regulations led to more controlled hunting and they included the protection of the Svalbard reindeer in 1925 and the establishment of guidelines in 1928 for hunting Svalbard rock ptarmigans (*Lagopus muta hyperborea*), geese (e.g., *Branta leucopsis* and *Branta bernicla*) and arctic foxes. The protection of the Svalbard reindeer, one of the main hunting species, increased the hunting pressure on the arctic fox population (Rossnes, 1993). The period from 1929-41 represents the highest documented impact on the arctic fox population in Svalbard. The number of harvested arctic foxes during this period were over 350 foxes annually and usually exceeded 400-500 individuals per season (Fuglei, 2015, unpubl. data). The evacuation of all inhabitants on Svalbard in 1941 ended this 22 years-period of intensive hunting pressure. The effect of hunting on Svalbard's arctic fox population during the interwar period is hard to evaluate because there are no records documenting a change in arctic fox occurrence on the archipelago. Nonetheless, it can be hypothesized that the non-declining numbers of trapped arctic foxes during this period (Fuglei, 2015, unpubl. data) suggests that the population was resilient and self-sustaining despite an organized hunting regime.

1.3 The Svalbard Treaty of 1920 and the Svalbard Act of 1925

The history of Svalbard has always been characterized by the interests of numerous nations claiming their sovereignty over the archipelago. However, its international status remained for the most part as nobody's land (*terra nullius*) (Avango et al., 2011; Brown, 1919; Wallis and Stewart, 2011). The first official recognition of Svalbard as *terra nullius* was in 1872 with an agreement between Russia and Sweden-Norway, which acknowledged the Russian and the European history of exploration in Svalbard (Vylegzhanin and Zilanov, 2007). The increasing mining activities of several countries on the archipelago after 1905 called for a conclusive regime in order to avoid disputes on legal claims. Furthermore, concerns about the state of the environment, described as the disappearing of Svalbard reindeer herds and reduced numbers of arctic foxes (Brown, 1919), highlighted the need to develop a legislative framework to prevent further overexploitation based on the 'tragedy of the commons' (Hardin, 1968).

Norway's diplomatic efforts, after their independence in 1905, aimed to reach a new legal status for Svalbard. These efforts culminated eventually in the Treaty on the Status of Spitsbergen (Svalbard Treaty) (Ministry of Foreign Affairs, 1920), which was signed in 1920 in Versailles at the Paris Peace negotiations and entered into force in 1925 with the Svalbard Act (Ministry of Justice and Public Safety, 1925) (Wallis and Stewart, 2011). This was the first time that a country, namely Norway, gained sovereignty over the archipelago and it also began its environmental protection. The Svalbard Treaty gave Norway the right to implement legislations and regulations for the exploitation of mineral resources (Ministry of Trade, Industry and Fisheries, 1925), as well as the responsibility '[...] to ensure the preservation and, if necessary, the re-constitution of the fauna and flora [...]' (Ministry of Foreign Affairs, 1920) on the territories of Svalbard. The cornerstone for environmental protection was laid and led soon to the establishment of two large plant protection reserves in 1932 (Table 2.2) (Ministry of the Environment, 1932). Despite the protection of the right to hunt in Article 2 of the Svalbard Treaty, Norwegian authorities in Svalbard paved the way to protect several species in the following decades, e.g., Svalbard reindeer (1925), walrus (1952), geese (1955), and eider ducks (1963) (St. meld. nr. 22, 1994-95).

The postwar period (1945-71) was characterized by a more moderate hunting effort (Table 2.1) with about 100 foxes hunted per year (Fuglei, 2015, unpubl. data). Despite the environmental initiatives and regulations mentioned above, there was no attempt to protect the arctic fox on Svalbard nor to institute a legal obligation to register the number of hunted foxes. This suggests that perhaps the arctic fox population during this period was not severely impacted and, hence, was not a major concern for the Norwegian authorities.

Table 1.1 Summary of the number of hunted arctic foxes in Svalbard from 1596 to 1971

Time period	Numbers of years with fox hunting data	Number of arctic foxes hunted in Svalbard
1596-1700 Early exploitation of Svalbard's natural resources	-	No hunting data available
1700-1852 Russian overwintering trapping	1	30
1795-1941 Norwegian overwintering trapping	45	11,774
1945-1971 Postwar period	18	1,724

1.4 Environmental protection in the 1970s

A milestone in protecting Svalbard's environment was reached in the 1970s with the Decree of the Ministry of Climate and Environment no. 3780 in 1973, which fostered the establishment of 3 national parks, 2 nature reserves, and 15 bird reserves (Ministry of Climate and Environment, 1973). In addition, Norway signed the Agreement on Conservation of Polar Bears in 1973 (Agreement on Conservation of Polar Bears, 1973) as a reaction to the declining numbers of polar bears worldwide. The complete ban on hunting polar bears, as well as the establishment of protected areas that at the time encompassed 40% of the terrestrial habitat, ended the exploitation of Svalbard's wildlife as an economic resource (Umbreit and Edmunds, 2009). Unfortunately, historical data on the number of harvested arctic foxes after these important changes are non-existent. It is likely, however, that locals living in Svalbard resumed hunting and trapping within the existing regulations but at a smaller scale. Ultimately, the lack of economic incentives and environmental restrictions ended the long tradition of commercial hunting in Svalbard (Umbreit and Edmunds, 2009).

These changes in the early 1970s (Table 2.2) showed the growing concern about Svalbard's natural environment and Norway's increased political interest in the archipelago (St. meld. nr. 39, 1974-75). Subsequently, Norway issued the Report on Svalbard 'Verdrørende Svalbard' (St. meld. nr. 39, 1974-1975) to the Norwegian Parliament (Storting) in 1975, with the intention to encourage and increase the involvement of the Norwegian authorities in Svalbard. This first White Paper on Svalbard's policy focused mainly on providing recommendations for administrative and mining issues (Thomassen, 2013), but also formulated the current state of environmental protection and its future role given the anticipated increase of natural resource exploitation in the polar regions (St. meld. nr. 39, 1974-75). The Svalbard Report emphasized Norway's international efforts regarding environmental issues in the Arctic such as the country's strong involvement in the International Union for Conservation of Nature (IUCN) Arctic Environmental Specialist Group in 1973 and Norway's approval to integrate Svalbard in the Man and the Biosphere (MAB) program by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Furthermore, the report described the current protection status of Svalbard's wildlife and nature as satisfactory, but stressed that further regulations needed to be implemented in order to reduce human induced impacts (e.g., mining, recreation, tourism) on Svalbard's fragile ecosystems.

The Svalbard Report goes hand in hand with other numerous international commitments by Norway in the 1970s to protect the environment in the country. The most important international agreements protecting terrestrial wildlife were the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Conservation of Migratory Species of Wild Animals (Bonn Convention), both of which came into force in 1979. Because the Bern Convention lists the arctic fox under the strictly protected fauna in Appendix II, which refers, *inter alia*, to the prohibition of capturing, keeping, and killing of listed species (Council of Europe, 1979), the Government of Norway (Regjeringen) declared in 1986 a reservation in regard to the conservation and management of arctic foxes on Svalbard (St. prp. nr. 12, 1985-86). This reservation was based on article 21 (§1) of the Bern Convention, which allows contracting parties to 'specify the territory or territories to which this Convention shall apply' (Council of Europe, 1979). In addition, it accounted for the difference between Svalbard's non-

endangered arctic fox population and Norway's critically endangered mainland population. This step allowed Norway the legal right to maintain its own legislations and regulations for Svalbard's arctic fox population without omitting the provisions of the Bern Convention. Despite this reservation, Norway promoted the protection of all migratory species listed in the Appendices II and III of the Bern Convention (St. prp. nr. 12, 1985-86) and it ensured its responsibility to maintain a healthy and self-sustaining arctic fox population in Svalbard.

A second report called 'Svalbard' (St. meld. nr. 40, 1985-86) was released in the mid-1980s, with the overall objective of having a consistent and firm enforcement of Norway's sovereignty under the Svalbard Treaty to ensure stability and peace in the region. The report also highlights the conservation of Svalbard's unique wilderness as one of the main goals for future policy actions (St. meld. nr. 40, 1985-86). Norway was concerned about Svalbard's nature in light of renewed international interest in exploiting Svalbard's mineral resources in the 1980s (Hansson et al., 1990). To avoid further degradation of Svalbard's environment, the Norwegian Polar Institute (Norsk Polarinstitutt) established in 1986 the Environmental Studies in Svalbard associated with Petroleum Activities, also known as the MUPS program (Miljøundersøkelser på Svalbard). During the 1980s the main focus of environmental protection was on the impact of industrial development in Svalbard. The MUPS program led to the development of the Assessment System for the Environment and Industrial Activities in Svalbard to study the potential effects of these activities on wildlife.

Hansson et al. (1990) generated an assessment report that focused on several environmental factors and designated the arctic fox as a Valued Ecosystem Component (VEC). The assessment report stated that based on several indicators from ongoing research in the 1980s on the arctic fox in Svalbard, the species seemed to be thriving on the archipelago. For example, the Nordenskiöld Land (600 square kilometers) represented an area with around 10-15 used dens annually and 100-150 individuals inhabiting the territories during late summer and autumn, which was considered as a thriving population. And despite the lack of any official records for fox hunting numbers during the 1980s, Hansson et al. (1990) estimated that about 200 foxes were trapped annually by approximately 10 active hunters, which was also an indicator for a viable arctic fox population in Svalbard. Hansson et al. (1990) recommended surveying, monitoring and researching the arctic fox population to successfully assess any human induced impacts on the species. They also recommended the examination of arctic foxes caught by hunters to determine effects of potential contamination and outbreak of diseases like rabies. The MUPS program was the first of its kind in Svalbard, and it officially recognized that further measurements were needed to evaluate the status of the arctic fox population on the archipelago.

1.5 Svalbard's Environmental Protection Act and the *status quo*

The 1990s represent a period with major changes in environmental policies in Norway (Table 2.2). With the ratification of the CBD in 1993, Norway agreed to actively engage in reducing the loss of biodiversity worldwide. To account for its commitment to conserve its own biodiversity, Arctic regions under Norwegian sovereignty were prioritized because of their untouched wilderness character (Ministry of Climate and Environment, 1998). This

prioritization of Arctic regions as pristine and distinctive nature was included in the 1995 status report on the environmental protection on Svalbard 'Om miljøvern på Svalbard' (St. meld. nr. 22, 1994-95). Such inclusion marked the first time when the protection of Svalbard's environment officially became the driving principle for future policies. This 1995 status report underlined that the CBD and its ratification by Norway had a significant effect on the development of Norway's guiding principles for environmental protection. The report's main objectives for future activities in Svalbard were twofold. Firstly, to develop Svalbard as one of the best managed wilderness areas of the world. Secondly, prioritize and weigh heavily environmental concerns when they conflict with other interests on the archipelago, so that they are a leading factor in the decision-making process (St. meld. nr. 22, 1994-95, St. meld. nr. 9, 1999-2000). To implement these important objectives, the 1995 status report recommended several actions for the future management of Svalbard, including a comprehensive monitoring of key environmental factors and management oriented research. Subsequently, Norwegian authorities stipulated in 1997 the Regulation on wildlife management on Svalbard 'Forskrift om forvaltning av vilt på Svalbard' (Ministry of the Environment, 1997) and introduced the requirement of purchasing a hunting license for all wild birds and land mammals and reporting the annual harvest of big game species, i.e., Svalbard reindeer and arctic fox, for research and management purposes. This required annual registration of hunted species represents the beginning of an inclusive research management program in Svalbard.

One of the first steps towards developing Svalbard as one of the best managed wilderness areas in the world was to examine the current state of knowledge on its environment. In order to allocate future management and research efforts efficiently, it was essential to focus on key components of Svalbard's ecosystems. One such component was the arctic fox, which was designated as one of four priority species/species group in Svalbard 'prioriterte artene/artsgruppene på Svalbard' (Fuglei et al., 1998). With the prioritization of the species, Fuglei et al. (1998) developed the first status report for the arctic fox in Svalbard. This report found that overall there was insufficient knowledge about the arctic fox population on the archipelago to accurately assess its actual status. Despite the lack of population assessments for the entire archipelago, Fuglei et al. (1998) believed the arctic fox population was in good condition. They also pointed out that it was important for the management of the species to study the effects of environmental (e.g., diseases) and human induced disturbances (e.g., hunting, pollution) by implementing long-term monitoring and research programs. Prior to the registration requirement of hunting in 1997, it was estimated that around 150-200 arctic foxes were hunted annually from 1986-96 (Fuglei et al., 1998). The report further described the hunting as a valuable contribution for future research on arctic foxes in Svalbard. The hunting, together with the implementation of new regulations (e.g., duty to report harvest numbers), allows better research and management planning for the species.

The environmental protection of Svalbard was further advanced with the release of the fourth report on Svalbard from 1999 'Svalbard' (St. meld. nr. 9, 1999-2000), which represented a comprehensive assessment of Svalbard's community in context with environmental issues, industries, foreign policies and other relevant matters (Table 2.2). Further, it led to the stipulation of the Svalbard Environmental Protection Act in 2002 (Ministry of Climate and Environment, 2012), which was the first official legislation that reinforced the outlaid objectives of the two status reports to the Storting in the 1990s (Thomassen, 2013).

Table 1.2 National and international legislative changes regarding environmental protection in Svalbard from 1925 to the present

Year	Legislative change
1925	Protection of Svalbard reindeer due to the stipulation of the Svalbard Act, which derived from the international Treaty on the Status of Spitsbergen (Svalbard Treaty) and gave Norway the responsibility '[...] to ensure the preservation and, if necessary, the re-constitution of the fauna and flora [...]' (Ministry of Foreign Affairs, 1920)
1932	Establishment of two large plant protection reserves
1952	Protection of walrus
1955	Protection of geese
1963	Protection of eider ducks
1973	Decree of the Ministry of Climate and Environment no. 3780, which fostered the establishment of 3 national parks, 2 nature reserves, and 15 bird reserves (Ministry of Climate and Environment, 1973) Norway signed the Agreement on Conservation of Polar Bears
1974-75	First White Paper on Svalbard's policy: Report on Svalbard 'Verdrørende Svalbard' (St. meld. nr. 39, 1974-1975), which formulated the current state of environmental protection and its role in future exploitation of natural resources in the Arctic
1979	Ratification of the Bern and Bonn Conventions
1986	Reservation in regard to the conservation and management of arctic foxes on Svalbard in accordance with article 21 (§1) of the Bern Convention
1986	Second report on Svalbard's policy, which highlighted the conservation of Svalbard's unique wilderness as one of the main goals for future policy actions
1993	Ratification of the Convention on Biological Diversity (CBD), which led to the prioritization of all Arctic regions under Norwegian sovereignty due to their untouched wilderness character
1995	Third status report on the environmental protection on Svalbard 'Om miljøvern på Svalbard' with the two main objectives to develop Svalbard as one of the best managed wilderness areas in the world
1997	Stipulation of the Regulation on wildlife management on Svalbard 'Forskrift om forvaltning av vilt på Svalbard'
1999	Fourth report on Svalbard 'Svalbard', which represented a comprehensive assessment of Svalbard's community in context with environmental issues, industries, foreign policies and other relevant matters
2002	Stipulation of the Svalbard Environmental Protection Act with the main objective to preserve a untouched environment
2012	Update of the Svalbard Environmental Protection Act, which entails all aspects on the environment in Svalbard regarding its utilization by humans and its protection

The main objective of the Svalbard Environmental Protection Act was the preservation of a ‘virtually untouched environment’ with the allowance of ‘environmentally sound settlement, research and commercial activities’ (Ministry of Climate and Environment, 2012). The Act was updated in 2012 and is up to the present Norway’s legislation, which deals with all aspects on the environment in Svalbard regarding its utilization by humans and its protection. The legislations represents a framework for all issues that deal with pollution, waste, harvesting, flora, fauna, cultural heritage, residents, and visitors. It is accompanied by several regulations that provide detailed information on, e.g., hunting and trapping provisions.

In 1999 the Environmental Monitoring of Svalbard and Jan Mayen (MOSJ) was founded, which considers the arctic fox as one of the indicators to assess the terrestrial environment (Sander et al., 2006). This environmental monitoring system accounts for both national (e.g., St. Meld. Nr. 9 of 1999-2000) and international obligations (e.g., the CBD) that Norway agreed to in order to preserve its own biodiversity. Since 1999 around 100-200 arctic foxes have been hunted every year, with a record number of about 320 foxes in 2008 (Norwegian Polar Institute, 2015). Moreover, a monitoring program was established in two areas of West Svalbard (Brøggerhalvøya/Kongsfjorden and Adventdalen/Sassendalen) to examine the population dynamics of foxes. This monitoring revealed that there is a consistent ‘year-to-year variation in population size’ and that the overall status of the arctic fox can be considered sustainable and viable (Ims et al., 2014). Up until now, the arctic fox in Svalbard is classified as a species of ‘Least Concern’. Since the arctic fox is a priority and indicator species in Svalbard, it is protected by only allowing its hunting only from 01 November to 15 March in six specified areas on the main island of Spitsbergen. Two of the six areas are near to the main settlement of Longyearbyen (Nordenskiöld Land, Oscar II Land). Another area is south of Longyearbyen (Nathorst Land), while the remaining three are north of Pyramiden (Andrée Land, Dickson Land, Ny-Friesland).

1.6 Conclusion

The archipelago of Svalbard is considered one of the few untouched wilderness areas in Europe. To account for its pristine nature, Norway has put forward an overarching goal to develop Svalbard as one of the best managed wilderness areas in the world. Currently, Norway has protected around 67% of the terrestrial habitat and 87% of the territorial waters of Svalbard (Ministry of Climate and Environment, 2014). Norway’s commitment in protecting biodiversity is shown through its adoption of comprehensive environmental policies (e.g., hunting regulations, waste management, mining restrictions, protected areas). In the light of climate change and its associated consequences, it is expected that the ecosystems in the Arctic will be heavily impacted because of their relatively simple and highly interdependent communities (ACIA, 2004). Hence, it is of great importance to establish a management system of these areas that allows proactive conservation actions. By integrating international environmental obligations into national legislations, Norway has contributed greatly to the protection of Svalbard.

The viable and stable arctic fox population in Svalbard is a stark contrast to the highly endangered arctic fox population in mainland Europe. Despite local intensive hunting efforts on the archipelago, research seems to indicate that there are no long-term effects on the survival of the arctic fox population. This is thought to be because of the population’s

ability to compensate for the loss of individuals either by having a high birth and survival rate or through immigration via sea ice (Fuglei et al., 2013; Geffen et al., 2007; Ims et al., 2014; Norén et al., 2011). However, climate change is causing the sea ice to retreat, which ultimately impacts the inflow of arctic foxes from other Arctic regions (Fuglei et al., 2013; Geffen et al., 2007; Ims et al., 2014, 2013; Norén et al., 2011). Hence, it is important to study the potential effects of the current hunting regime together with future climatic changes. Furthermore, it is of great concern that diseases like rabies are imported through immigration of arctic foxes from other regions to Svalbard (Mørk et al., 2011; Norén et al., 2011). Given that rabies is a threat to both arctic foxes and humans living on the archipelago, it is essential to systematically monitor this disease in Svalbard. The Norwegian Veterinary Institute and the Norwegian Polar Institute have monitored the abundance of rabies in Svalbard by examining all trapped foxes (1997-2002) and in foxes found dead (1995-2003) (Mørk et al., 2011). After the recent rabies outbreak in 2011, funding has been provided to analyse trapped foxes from before and after the outbreak (Mørk et al., 2011). Developing a surveillance system for early detection of rabies will help manage potential outbreaks to prevent the spread of the disease among the entire arctic fox population (and other wildlife) and the human settlements on the archipelago (Mørk et al., 2011). The hunting of arctic foxes can therefore be an important management strategy to integrate such a surveillance system. Hunters are most likely to detect changes in arctic fox behaviour due to rabies given their knowledge of the terrain and the species. Further, a continuous examination of trapped foxes and foxes found dead can provide valuable information about the health of each individual and help determine the extent of possible rabies outbreaks in the future. However, it has to be guaranteed that hunting efforts are not detrimental to the long-term survival of arctic foxes. If the hunting of arctic foxes is ultimately pursued only as a recreational activity in Svalbard, where harsh environmental conditions dominate and the ecosystems are very vulnerable to climate change, it also has to be closely monitored to avoid unintended effects on Svalbard's terrestrial community.

Given Norway's goal to develop Svalbard as one of the best managed wilderness areas in the world, Svalbard's arctic fox population can play an important role in future management actions by providing key information on the health of Svalbard's ecosystems. However, it has to be pointed out that monitoring the arctic fox in only two areas of the archipelago, only represents a small fraction of Svalbard's entire arctic fox population. Despite the difficulties to establish and conduct studies in the high Arctic, it is essential to expand existing research efforts. Although, the current research is used as an indicator for the entire arctic fox population, the actual population size and the potential effects of climate change on it remain unknown. Hence, a comprehensive research regime for Svalbard's entire arctic fox population is needed to address these data gaps. Only with this information will it be possible to plan and realize proactive management actions, and help develop Svalbard as one of the best managed wilderness areas.

The slow and limited recovery of arctic foxes on the Norwegian mainland, despite decades of conservation efforts, serves as a cautionary tale of the problems and risks associated with conserving small populations (e.g., hard and expensive to restore, greater risk of extinction). Of course, the present situation in Svalbard is not entirely comparable to that of mainland Europe in the first half of the 20th century, because of today's low economic incentives and comprehensive regulations that lead to low hunting pressure in Svalbard. Nonetheless, it is important to acknowledge and plan accordingly for future potential

threats to the arctic fox population due to climatic changes. Furthermore, human interests in the Arctic are increasing given the environmental changes occurring in the region (e.g., warming temperatures, decrease of sea ice, easier accessibility of natural resources). Svalbard, therefore, plays an important role in curbing the increasing demand for resource exploitation and development of the Arctic. By taking an active conservation approach for the arctic fox in Svalbard, Norway shows commitment to protect the nature in the Arctic. Svalbard can serve as a management model to help to protect arctic fox populations on other Arctic islands. Finally, Norway becomes a stronger actor on claiming its sovereignty over Svalbard by adopting comprehensive environmental policies, because they address environmental concerns both for the archipelago and the entire Arctic region.

1.7 References

- ACIA, 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge.
- Agreement on Conservation of Polar Bears, 1973. URL: <http://sedac.ciesin.org/entri/texts/polar.bears.1973.html> (accessed 8.20.15).
- Angerbjörn, A., Hersteinsson, P., Tannerfeldt, M., 2004. Europe and North and Central Asia (Palearctic): Arctic fox (*Alopex lagopus*), in: Sillero-Zubiri, C., Hoffmann, M., Macdonald, D.W. (Eds.), *Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan*. IUCN/SSC Canid Specialist Group. Gland, Switzerland and Cambridge, UK.
- Angerbjörn, A., Tannerfeldt, M., 2014. *Vulpes lagopus*. IUCN Red List Threat. Species. URL: www.iucnredlist.org (accessed 5.7.15).
- Audet, A.M., Robbins, C.B., Larivière, S., 2002. *Alopex lagopus*. *Mamm. Species* 1–10. doi:10.2307/3504336
- Avango, D., Hacquebord, L., Aalders, Y., De Haas, H., Gustafsson, U., Kruse, F., 2011. Between markets and geo-politics: natural resource exploitation on Spitsbergen from 1600 to the present day. *Polar Rec. (Gr. Brit)*. 47, 29–39. doi:<http://dx.doi.org/10.1017/S0032247410000069>
- Brown, R.N.R., 1919. Spitsbergen, Terra Nullius. *Geogr. Rev.* 7, 311–321. doi:10.2307/207588
- Callaghan, T. V., Björn, L.O., Chernov, Y., Chapin, T., Christensen, T.R., Huntley, B., Ims, R.A., Johansson, M., Jolly, D., Jonasson, S., Matveyeva, N., Panikov, N., Oechel, W., Shaver, G., Elster, J., Henttonen, H., Laine, K., Taulavuori, K., Taulavuori, E., Zöckler, C., 2004. Biodiversity, Distributions and Adaptations of Arctic Species in the Context of Environmental Change. *AMBIO A J. Hum. Environ.* 33, 404–417. doi:10.1579/0044-7447-33.7.404
- Council of Europe, 2007. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
- Council of Europe, 1979. Bern Convention on the Conservation of European Wildlife and Natural Habitats.

- Dalén, L., Götherström, A., Tannerfeldt, M., Angerbjörn, A., 2002. Is the endangered Fennoscandian arctic fox (*Alopex lagopus*) population genetically isolated? *Biol. Conserv.* 105, 171–178. doi:10.1016/S0006-3207(01)00180-X
- Finnish Ministry of the Environment, 2010. Punainen lista [e. The Red list]. URL: [http://www.ymp.fi/fi-FI/Ajankohtaista/Julkaisut/Erillisjulkaisut/Suomen_lajien_uhanalaisuus__Punainen_kir\(4709\)](http://www.ymp.fi/fi-FI/Ajankohtaista/Julkaisut/Erillisjulkaisut/Suomen_lajien_uhanalaisuus__Punainen_kir(4709)
- Frankham, R., 1997. Do island populations have less genetic variation than mainland populations? *Heredity (Edinb)*. 78 (Pt 3), 311–327. doi:10.1038/sj.hdy.6880980
- Fuglei, E., 2015. Number of foxes trapped in Svalbard (1824-1971). Tromsø, unpublished data.
- Fuglei, E., Ims, R.A., 2008. Global warming and effects on the arctic fox. *Sci. Prog.* 91, 175–191.
- Fuglei, E., Meldrum, E.A., Ehrich, D., 2013. Effekt av fangst – fjellrev på Svalbard [e. Effects of hunting - Arctic foxes in Svalbard].
- Fuglei, E., Prestrud, P., Vongraven, D., 1998. Status of the Arctic fox *Alopex lagopus* in Svalbard [no. Status For Fjellrev *Alopex lagopus* På Svalbard].
- Geffen, E.L.I., Waidyaratne, S., Dalén, L., Angerbjörn, A., Vila, C., Hersteinsson, P., Fuglei, E., White, P.A., Goltsman, M., Kapel, C.M.O., 2007. Sea ice occurrence predicts genetic isolation in the Arctic fox. *Mol. Ecol.* 16, 4241–4255.
- Gilg, O., Sittler, B., Hanski, I., 2009. Climate change and cyclic predator–prey population dynamics in the high Arctic. *Glob. Chang. Biol.* 15, 2634–2652. doi:10.1111/j.1365-2486.2009.01927.x
- Hansson, R., Prestrud, P., Øritsland, N.A., 1990. Assessment System for the Environment and Industrial Activities in Svalbard. Oslo.
- Hardin, G., 1968. The Tragedy of the Commons. *Science (80-)*. 162, 1243–1248. doi:10.1126/science.162.3859.1243
- Hersteinsson, P., 2006. Íslenski tófustofninn [e. The Icelandic Arctic fox population], in: *Veiðidagbók 2006*. The Environment Agency of Iceland, Reykjavík, pp. 6–15.
- Hersteinsson, P., Angerbjörn, A., Frafjord, K., Kaikusalo, A., 1989. The arctic fox in fennoscandia and Iceland: Management problems. *Biol. Conserv.* 49, 67–81. doi:10.1016/0006-3207(89)90113-4
- Ims, R.A., Alsos, I.G., Fuglei, E., Pedersen, A.Ø., Yoccoz, N.G., 2014. An assessment of MOSJ - The state of the terrestrial environment in Svalbard. Tromsø: Norsk Polarinstitutt. Rapportserie, 144.
- Ims, R.A., Jepsen, J.U., Stien, A., Yoccoz, N.G., 2013. Science plan for COAT: Climate-ecological Observatory for Arctic Tundra. Fram Centre Report Series 1, Fram Centre, Norway.

- IUCN, 2009a. Species and climate change: More than just the Polar Bear. URL: <https://portals.iucn.org/library/sites/library/files/documents/2009-051.pdf> (accessed 7.15.15).
- IUCN, 2009b. Arctic foxes and climate change: Out-foxed by Arctic warming. URL: http://cmsdata.iucn.org/downloads/fact_sheet_red_list_arctic_foxes.pdf (accessed 5.7.15).
- Johansen, B.F., Prestvold, K., Overrein, Ø., 2011. Cruise Handbook for Svalbard, Polar handbook. Norwegian Polar Institute.
- Lønø, O., 1972. Norsk fangstmenns overvintringer Del I - 1795 til 1892 [e. The Norwegian winter hunting expeditions Part I - 1795 to 1892]. Nor. polarinstitutt Meddelelse.
- MacDonald, E., Handeland, K., Blystad, H., Bergsaker, M., Fladberg, M., Gjerset, B., Nilsen, O., Os, H., Sandbu, S., Stokke, E., 2011. Public health implications of an outbreak of rabies in arctic foxes and reindeer in the Svalbard archipelago, Norway, September 2011. Euro Surveill 16.
- Ministry of Climate and Environment, 2015. Forskrift om fjellrev som prioritert art etter naturmangfoldloven [e. Regulation on the Arctic fox as a priority species under the Nature Diversity Act]. URL: https://www.regjeringen.no/contentassets/f057113d975a4e3780333d5676774cbb/fjellrev_kongeligres.pdf (accessed 8.20.15).
- Ministry of Climate and Environment, 2014. Norway's Fifth National Report to the Convention on Biological Diversity.
- Ministry of Climate and Environment, 2012. Lov om miljøvern på Svalbard [e. Svalbard Environmental Protection Act]. URL: <https://lovdata.no/dokument/NL/lov/2001-06-15-79> (accessed 8.20.15).
- Ministry of Climate and Environment, 1998. Norway's National Report on the Implementation of the Convention on Biological Diversity.
- Ministry of Climate and Environment, 1973. Forskrift om opprettelse av fuglereservater og større naturvernområder på Svalbard [e. Regulation on the establishment of bird reserves and large protected areas on Svalbard]. URL: <https://lovdata.no/dokument/SFO/forskrift/1973-06-01-3780> (accessed 8.15.15).
- Ministry of Foreign Affairs, 1920. Svalbardtraktaten [e. Svalbard Treaty]. URL: <https://lovdata.no/dokument/NL/lov/1920-02-09> (accessed 8.20.15).
- Ministry of Justice and Public Safety, 1925. Svalbardloven [e. Svalbard Act]. URL: <https://lovdata.no/dokument/NL/lov/1925-07-17-11> (accessed 8.19.15).
- Ministry of the Environment, 1997. Forskrift om forvaltning av vilt på Svalbard [e. Regulation on wildlife management on Svalbard]. URL: <https://lovdata.no/pro/#document/SFO/forskrift/1996-05-24-516> (accessed 8.20.15).
- Ministry of the Environment, 1932. Forskrift om opprettelse av 2 plantefredningsområder på Svalbard [e. Regulations relating to the establishment of two plant protection

- reserves on Svalbard]. URL: <https://lovdata.no/dokument/SFO/forskrift/1932-02-26-3764> (accessed 8.18.15).
- Ministry of Trade Industry and Fisheries, 1925. Bergverksordning for Svalbard [e. Mining Code for Svalbard]. URL: <https://lovdata.no/dokument/NL/lov/1925-08-07> (accessed 8.18.15).
- Mørk, T., Bohlin, J., Fuglei, E., Åsbakk, K., Tryland, M., 2011. Rabies In The Arctic fox Population, Svalbard, Norway. *J. Wildl. Dis.* 47, 945–957. doi:10.7589/0090-3558-47.4.945
- Norén, K., Angerbjörn, A., Hersteinsson, P., 2009. Population structure in an isolated Arctic fox, *Vulpes lagopus*, population: the impact of geographical barriers. *Biol. J. Linn. Soc.* 97, 18–26. doi:10.1111/j.1095-8312.2009.01172.x
- Norén, K., Carmichael, L., Fuglei, E., Eide, N.E., Hersteinsson, P., Angerbjörn, A., 2011. Pulses of movement across the sea ice: population connectivity and temporal genetic structure in the arctic fox. *Oecologia* 166, 973–984.
- Norwegian Biodiversity Information Centre, 2010a. Norsk Rødliste for arter 2010 [e. The 2010 Norwegian Red List for Species]. URL: [http://www.artsdatabanken.no/File/685/Norsk r%C3%B8dliste for arter 2010](http://www.artsdatabanken.no/File/685/Norsk_r%C3%B8dliste_for_arter_2010) (accessed 8.20.15).
- Norwegian Biodiversity Information Centre, 2010b. Norsk Rødliste for arter 2010 [e. The 2010 Norwegian Red List for Species]. URL: <http://www.artsdatabanken.no/Databank?query=fjellrev> (accessed 8.20.15).
- Norwegian Polar Institute, 2015. Bag of Arctic foxes (*Vulpes lagopus*). URL: <http://mosj.npolar.no/en/influence/hunting/indicators/arctic-fox-hunting.html> (accessed 8.20.15).
- Nuttall, M., 2012. *Encyclopedia of the Arctic*. Routledge, New York and London.
- Rossnes, G., 1993. Norsk overvintringsfangst på Svalbard 1895-1940 [e. The Norwegian overwintering trapping in Svalbard 1895-1940]. *Nor. polarinstitutt Meddelelse*.
- Sander, G., Hanssen-Bauer, I., Bjørge, A., Prestrud, P., 2006. *The Environmental Monitoring of Svalbard and Jan Mayen – MOSJ: Documentation of the system and the first assessments of the state of the environment*. Tromsø: Norsk Polarinstitutt. Rapportserie, 123.
- Scholander, P.F., Hock, R., Walters, V., Irving, L., 1950. Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation, and basal metabolic rate. *Biol. Bull.* 99, 259–271.
- St. meld. nr. 22, 1994-95. Oslo: Miljøverndepartementet.
- St. meld. nr. 39, 1974-75. Oslo: Justis- og Politidepartement.
- St. meld. nr. 40, 1985-86. Oslo: Justisdepartementet.
- St. meld. nr. 9, 1999-2000. Oslo: Justis- og Politidepartement.

St. prp. nr. 12, 1985-86. Oslo: Utenriksdepartementet.

Swedish Species Information Centre, 2015. ArtDatabanken: *Vulpes lagopus* Fjällräv [e. SpeciesDatabase: *Vulpes lagopus* Arctic fox]. URL: <http://artfakta.artdatabanken.se/taxon/100005>

Thomassen, I.C., 2013. The Continental Shelf of Svalbard: Its Legal Status and the Legal Implications of the Application of the Svalbard Treaty Regarding Exploitation of Non-Living Resources. UiT - The Arctic University of Norway.

Umbreit, A., Edmunds, D., 2009. Spitsbergen, Bradt Guides. Bradt Travel Guides.

UNESCO, 2007. Tentative Lists: Svalbard Archipelago. URL: <http://whc.unesco.org/en/tentativelists/5161/> (accessed 7.10.15).

Vylegzhanin, A.N., Zilanov, V.K., 2007. Spitsbergen: legal regime of adjacent marine areas. Eleven International Pub., Utrecht.

Walker, M.D., Wahren, C.H., Hollister, R.D., Henry, G.H.R., Ahlquist, L.E., Alatalo, J.M., Bret-Harte, M.S., Calef, M.P., Callaghan, T. V, Carroll, A.B., 2006. Plant community responses to experimental warming across the tundra biome. *Proc. Natl. Acad. Sci. U. S. A.* 103, 1342–1346.

Wallis, D., Stewart, A. (Eds.), 2011. The Spitsbergen Treaty: Multilateral Governance in the Arctic. *Arctic Papers Vol. 01.*

2 Management of the arctic fox in Iceland

2.1 Introduction

The arctic fox (*Vulpes lagopus*) thrives in cold climates in all tundra habitats in the Arctic (Angerbjörn and Tannerfeldt, 2014) and is the most common fox species inhabiting the arctic region (Audet et al., 2002). The species is classified as ‘Least Concern’ by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2013), and it has no protection status in most of its range (Angerbjörn and Tannerfeldt, 2014; Angerbjörn et al., 2004). The arctic fox is, however, given full protection in Europe since it is considered a priority species under the Actions by the Community relating to the Environment (ACE) (Angerbjörn and Tannerfeldt, 2014). Furthermore, the IUCN highlighted in 2009 the arctic fox as one of ten new flagship species that represent climate change and its impacts on the tundra habitat in the Arctic regarding habitat loss, increased red fox (*V. vulpes*) competition, and changes in prey abundance (IUCN, 2009a, 2009b).

As one of the top predators of the Arctic territories, the health of arctic fox populations can be seen as an indicator of current and future health status of Arctic ecosystems (Gilg et al., 2009; IUCN, 2009a). Moreover, conserving species diversity is regarded as one of the fundamental requirements of ecosystem stability (Mills et al., 1993). However, the species diversity of the highly interdependent predator-prey communities in the Arctic are likely to be affected faster and more strongly by global climate change than any other communities in the world (ACIA, 2004). Hence, the predicted impacts of global climate change on the Arctic are expected to influence both the distribution and abundance of arctic foxes (Callaghan et al., 2004; Fuglei and Ims, 2008; IUCN, 2009a, 2009b).

The populations of arctic foxes living on islands are considered to be more resilient towards the effects of climate change, because these island locations will likely face habitat changes later than mainland areas (IUCN, 2009a). Research, however, shows that island populations often have lower genetic diversity (Frankham, 1997; IUCN, 2009a), which may result in poor recovery potential after a bottle-neck event caused by, e.g., disease or hunting efforts (IUCN, 2009a). Despite these concerns, islands that are without competitor species like the red fox, which outcompetes the arctic fox under milder climate conditions, may be ideal as safe sanctuaries for arctic foxes (Fuglei and Ims, 2008). One such island is Iceland, making it an important priority for this country to ensure that its native arctic fox population is healthy and genetically diverse. Given the impacts of climate change, Iceland might become one of the few places where arctic foxes may survive in the long run. This further highlights Iceland’s global responsibility to conserve this species. Although the Icelandic arctic fox population is estimated at about 8,000 individuals and is showing a decrease in population size for the first time in 30 years (Unnsteinsdóttir, 2014), there is no management plan for this species in Iceland.

A lack of a management plan is of great concern, because the arctic fox population in Iceland has fluctuated significantly in the last centuries. For example, the population declined in the 1960s and early 1970s, having only 1,000-1,300 individuals in the autumn of 1970 but grew from there on and exceeded 10,000 individuals in 2008 (Angerbjörn et al., 2004; Hersteinsson, 2006; Ministry for the Environment and Natural Resources, 2011). The cause behind this drastic decline is most likely due to a combination of unfavorable weather conditions causing a decline in prey species, in addition to the implementation of the most efficient law no. 52/1957 on the eradication of arctic foxes and minks (*Neovison vison*) in 1957 (Alþingi, 1957) to prevent damages from both species (Hersteinsson et al., 1989; Mellows et al., 2012). Moreover, research indicates that the genetic diversity within small or isolated populations of wild animals is in general vulnerable to human disturbance (Mellows et al., 2012). Recovery of small populations can be difficult, as seen in the overhunted population of arctic foxes in Fennoscandia, where the population was reduced to <100 individuals, and has only recovered to less than 200 individuals despite strong conservation efforts (Angerbjörn et al., 2012; Dalén et al., 2002). Research on the wild arctic fox population in Fennoscandia shows that the small population in Norway has a lower genetic variation compared to larger populations in Svalbard and Siberia (Strand et al., 1998). This case illustrates that the arctic fox can be vulnerable to overhunting, raising concerns about the population in Iceland, which is hunted without a management plan in place. The Icelandic arctic fox population has recovered by growing tenfold since the last population bottleneck in the 1960s and early 1970s and is therefore considered resilient and allowed to be hunted (Angerbjörn et al., 2004; Hersteinsson, 2006); however, its genetic diversity remains comparable to that of the threatened population in Fennoscandia (Norén et al., 2009). Hence, the arctic fox population in Iceland has low evolutionary flexibility which makes it vulnerable to environmental changes and diseases in the future.

National legislations, e.g., the Nature Conservation Act (no. 60/2013) and the Protection and Hunting of Wild Species Act (no. 64/1994) (Alþingi, 2013a, 2013b), and international legislations, e.g., the Convention on Biological Diversity (CBD) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), commit Iceland to actively ensure the protection of its biodiversity of the native fauna and flora. Given the fact that Iceland has not yet implemented a conservation management plan for its only native terrestrial mammal (i.e., the arctic fox), shows that the legislations have not been fully applied in Iceland's policies. To manage arctic foxes as other wildlife, long-term knowledge about its distribution and migration patterns is essential. Further, it has to be guaranteed that Iceland's largest times series (>50 years) on population dynamics, breeding effort and survival will be continued in order to detect responses to changes in the environment and ensure a healthy and sustainable population. In addition, monitoring is needed on the effects on arctic foxes of culling, organic pollutants, and other environmental disturbances like parasite and pathogens.

This study aims to provide a much needed overview of arctic fox management in Iceland by reviewing existing literature and legislations. Its purpose is to give an insight into both the historical background and the current legislation status of arctic foxes in Iceland and the ongoing planned changes of these legislations. The main goals of this review are to identify (1) how international obligations have been implemented into national legislations, (2) how these national legislations are currently addressed into policies, and (3) if these legislations and policies are in line with international treaties signed by Iceland. Critical to the long-term viability of the arctic fox population in Iceland, is to assess if the national

legislations are sufficient in providing a realistic management framework that ensures a self-sustaining and resilient population in the coming decades. Finally, this review aims to identify knowledge gaps that limit effective conservation actions for Iceland's arctic fox population.

2.2 Historical Overview

The arctic fox has long been hunted in all of its range for its extraordinary fur, which is known to be one of the best insulating fur of all mammals (Scholander et al., 1950). Also, hunting mammals for their fur was for a long time a cultural tradition of the early Nordic settlers of Iceland (>1,100 years ago), even before they arrived to the island (Hersteinsson, 1980). Fox hunting in Iceland is considered part of the Icelandic heritage (Hersteinsson, 2006). Two reasons in particular explain why fox hunting has such a long and strong tradition in Iceland: the utilization of the species' valuable fur, and the prevention of damage to livestock caused by foxes (Hersteinsson, 1980; Schmalensee et al., 2013). Currently, there is only one comprehensive short paper in Icelandic (Hersteinsson, 1980) that focuses on the history of arctic fox management in Iceland. More information can be found in a few other papers and reports (e.g., Hersteinsson, 2006, 1980b; Schmalensee et al., 2013). The following two sub-sections will review existing information on the historical development of arctic fox management in Iceland. This historical overview will contribute to a better understanding of today's legislations and policies in Iceland.

2.2.1 Management of the arctic fox from 930 to 1994

Since the beginning of the Norse settlement in Iceland (9th century), as well as during and after the period known as the Icelandic Commonwealth (þjóðveldistími), which begins with the establishment of the National Parliament of Iceland (Alþingi) in 930 and ends with the unification with Norway in 1262, the fur from arctic foxes was worth as much as sheep's wool (Hersteinsson, 1980). Hence, it was a valuable good for trading and was used as currency (Unnsteinsdóttir, 2013). In addition, early sources like the collection of laws in Grágás (ca. 1260 – 1280) and the law of Iceland compiled in Jónsbók (1281) state that foxes were considered offenders to nature (skaðvaldur) and were described to be unholy to every man's land (Hersteinsson, 1980).

In 1295, the National Parliament of Iceland approved a legislation that regulated the hunting of foxes (Table 1.1). It claimed that every farmer that owned six sheep (or more) during the winter time was responsible to hunt either one adult fox or two young foxes per year (Hersteinsson, 1980). Furthermore, if a farmer decided not to hunt arctic foxes, the legislation stated that the farmer had to pay a fine of two 'álnir', which equals 4kg of prepared fish (Hersteinsson, 1980). This fine was called the fox tax (dýratollur) and was used to both pay a hunter and to compensate for the damages caused by arctic foxes (Hersteinsson, 1980).

The fox legislation was renewed by the National Parliament of Iceland in 1485, 1680, 1780, and 1792 without any changes (Hersteinsson, 1980; Unnsteinsdóttir, 2013). Only in 1792 was a new detailed regulation passed regarding den hunting (grenjaleitir) in Borgarfjarðarsýslu (former county of Vesturland, Iceland), which is considered to be an example for further regulations concerning the hunting of foxes throughout Iceland (Schmalensee et al., 2013). The parliamentary renewals of the fox legislation from 1485-

1792 were a reminder to farmers of their fox hunting obligations. This obligation was even stated in the law book of Jón Jónsson (Formálabók Jóns lögmanns Jónssonar) from 1570-1581: 'I would like to remind farmers to go hunt foxes [dýr, refers to foxes as 'a beast'] as the men of Althingi have already agreed upon' (Hersteinsson, 1980). The need to remind farmers of their obligation was perhaps based on low arctic fox numbers at that time and, hence, low predation pressure on livestock. But it can also be pointed out that this reminder may have its origin in the existing contradiction regarding payment of implementing the law between farmers and fox hunters. Farmers were required to search for fox dens in the springtime on their land, but at their own expense. In contrast, fox hunters were paid for hunting foxes (Hersteinsson, 1980). In addition, the natural disaster of the Laki eruption (móðuharðindin) in 1783-1785 led to a royal directive in 1789, which stated that a prize would be given to anybody who would invent a fox trap (Schmalensee et al., 2013). Given that 75% of sheep livestock and every fifth Icelander (ca. 10,000) died during this natural disaster, the threat of foxes to livestock (búsifjar; when sheep are killed) became an even more important issue. Although arctic foxes might have equally suffered during the Laki eruption due to pollution and a lack of food, the potential threat to livestock stood out because of the severe conditions in which humans had to survive during this time period. The Laki eruption helps explain the development of the new fox den regulation in 1792 as an attempt to enhance the success of fox hunting and to ensure the survival of livestock. Moreover, it shows that the overall relationship Icelanders have towards the arctic fox is strongly influenced by the harsh conditions of living on an isolated island in the North Atlantic.

In 1809, the governors (amtmaður: highest ranking position held in office in Iceland during 1684-1904) gave instructions to the municipal administrative offices (hreppstjórar) about fox hunting (Schmalensee et al., 2013). These were according to a royal decree from 1808, and involved more precise regulations on how to hunt foxes, wages to fox hunters, and fines for farmers not fulfilling their hunting obligations (Hersteinsson, 1980; Schmalensee et al., 2013). Major changes were made to the royal decree in 1834, when it was stipulated that all farmers had to pay the fox tax, regardless if they hunted foxes or not, in order to maintain the hunting efforts (Hersteinsson, 1980). The changes also included that both farmers hunting dens and fox hunters were to be paid with money collected from the fox tax (Hersteinsson, 1980). From the beginning of the fox legislation (1295) and up until 1890, the money for fox hunting and compensation came solely from the fox tax. However, in 1890 the law was changed so that the expenses for fox hunting would also be paid from municipality funds (sveitasjóður) (Hersteinsson, 1980). Subsequently, after 1890 the changes in the legislation have dealt mainly with how the expenditures of fox hunting are covered, with the government picking up more of the costs over time and leading to a change in the financial responsibility from the farmers to the municipalities (Hersteinsson, 1980).

Iceland's perception towards its wildlife was exclusively based on utilization and/or potential damage to livestock (Schmalensee et al., 2013). This changed, however, in 1882 when the first protection law for birds was passed. Another regulation milestone occurred in 1886 with the implementation of the protection of whales into the national legislations (Schmalensee et al., 2013). Similarly, in 1913 a law was stipulated to protect breeding bird species that were endangered in the country. Despite these wildlife legislations, the status of the arctic fox as a vermin that needed to be eradicated remained the same.

Various methods were used to hunt arctic foxes in Iceland. The most common methods until mid-18th century were stone traps used in the wintertime and placing smoke inside active fox dens in the springtime (Hersteinsson, 1980). Further, the use of simple front loaded shotguns (framhlaðningur) in the early stages changed the arctic fox hunting by making it possible that foxes then could be killed on a longer distance. After the 1750s, new methods such as poisoning foxes or using hunting dogs (dýrhundar) were promoted and often used throughout Iceland. Although new hunting methods were used, the fox population increased. A magazine article from 1913 alluded to the effectiveness of poisoning foxes with the following statement from Jón Guðmundsson (a local from Ljárskógar) ‘the keenest observers, roughest animals and best hunters will leave the poison behind’ (Hersteinsson, 1980). This sentiment seems to have been shared by many Icelanders and reveals the perception of the arctic fox as a vermin with strong traits to survive even human pressure (Hersteinsson, 1980). Nonetheless, poisoning still remained a viable method to eradicate arctic foxes in Iceland.

In the 20th century there was further development of Iceland’s legislation with the new law no. 56/1949 on the eradication of the arctic fox and the mink (Alþingi, 1949) and its various amendments throughout the decades (Table 1.1). With this new law, fox poisoning became a legal obligation every third year. It was not until this law was amended in 1955, becoming law no. 10/1955 (Alþingi, 1955), that poisoning foxes (and minks) became a yearly obligation for property owners (Schmalensee et al., 2013). Both law no. 56/1949 and its amendment no. 10/1955 were replaced in 1957 with the implementation of law no. 52/1957 in 1957 (Alþingi, 1957). This new law changed the administration of the hunting efforts by introducing a hunting management office (Veiðistjóraembættið), which appointed a hunting supervisor at the former Agricultural Association of Iceland (Búnaðarfélag Íslands) for each municipality (Schmalensee et al., 2013). This was a major change as it led to organizing the hunting efforts with standardized hunting procedures, gathering information about population numbers, and experimenting with new hunting methods (Schmalensee et al., 2013). This new organization of the hunting efforts brought about the most successful fox extermination effort that has been recorded in Iceland, reducing the arctic fox population to as low as 1,000-1,300 individuals (Hersteinsson et al., 1989; Mellows et al., 2012). The use of poisoning was stopped in the 1960s with the amendments no. 9/1964 (Alþingi, 1964) and no. 43/1969 (Alþingi, 1969) to the law no. 52/1957. Poisoning was having a severe effect on the population of the white-tailed eagle (*Haliaeetus albicilla*) in Iceland. Since these two amendments, foxes have not been legally poisoned in Iceland (Schmalensee et al., 2013). Although, the existing literature does not conclude that the abolition of poisoning was the reason for the recovery of the arctic fox population in Iceland after 1970, it can be hypothesized that there is a relationship between these two events. Nonetheless, hunting arctic foxes to prevent damages to livestock still remained the main concern of managing this species in Iceland until the 1990s because the eradication plan was still in action.

At the same time as these profound changes in arctic fox management were taking place, the first comprehensive law on nature conservation no. 48/1956 (Alþingi, 1956) was implemented, representing a significant milestone in Iceland’s legislation (Alþingi, 1999). Furthermore, this new law provided the foundation of provisions for future legislations on nature conservation in the country (Alþingi, 1999). One reason for the Icelandic parliament to stipulate a new law on nature conservation was the ratification of the International

Convention for the Protection of Birds (Paris Convention of 1950) in 1956 (Alþingi, 1999). These events show a rising interest for conservation issues in Iceland.

The nature conservation law no. 48/1956 underwent various revisions until the 1990s. These revisions were also accompanied by several other laws that directly or indirectly referred to conservation and the interaction of man and nature. For instance, law no. 20/1972 on the prohibition of the release of hazardous substances into the sea, law no. 51/1981 on the prevention of diseases and pests in plants, law no. 52/1988 on toxic and hazardous substances, and law no. 52/1989 on the prevention of environmental pollution caused by disposable packaging for beverages (Alþingi, 1999). The establishment of the Ministry for the Environment (later Ministry for the Environment and Natural Resources) in 1990 marks an important milestone in Iceland's legislation history and ushered a decade of major changes regarding environment laws. The creation of this ministry was the first time that Iceland dedicated an entire institution to its environment and natural resources, changing significantly the country's perception and legislation on nature. The arctic fox management was now an administrative task of the Ministry for the Environment, which issued the 'central highland' line in 1991. This line protected the arctic fox in large areas of the highlands as no governmental subsidies were paid for fox hunting in the highlands. The Ministry for the Environment, furthermore, was instrumental in Iceland's ratification of the CBD and Bern Convention and the development of the Protection and Hunting of Wild Species Act (no. 64/1994) (Alþingi, 2013b) of 1994, which adapted important sections of the Bern Convention.

2.2.2 The new legislations of 1994 and the Nature Conservation Act

The arctic fox has been seen as a pest that needs to be eradicated to prevent damages to highly valuable livestock since the settlement of Iceland. Throughout history all the legislations regarding wild animals in Iceland revolved solely on human interests (Schmalensee et al., 2013). However, starting in the 1990s (Table 1.1) Iceland's attitude changed dramatically (Alþingi, 1999). The Protection and Hunting of Wild Species Act (no. 64/1994) (Alþingi, 2013b) marks a significant change in Icelandic legislation regarding the arctic fox. For the first time ever, the arctic fox was granted protection status by the Icelandic government with this law (Ministry for the Environment and Natural Resources, 2011; Schmalensee et al., 2013; Unnsteinsdóttir, 2013). The aim of this law was to ensure viability and diversity of wild populations, to manage hunting and utilization of wildlife and to take action to prevent potential damage caused by wild animals. The three main pillars of this legislation, (1) protection, (2) conservation, and (3) hunting, attempt to implement the protection and conservation of wild birds and mammals without omitting the long standing tradition of hunting in Iceland. To understand fully this attempt to combine protection with hunting, it is necessary to look at the three main pillars of law no. 64/1994.

According to law no. 64/1994 the first pillar, protection of wild birds and wild mammals, is outlined as the protection of certain species against the actions of humans. Specifically, it refers to hunting and any other actions (e.g., human disturbance during the breeding season) in such a way that the long-term survival of the population is not compromised. The law defines wild animals as all birds and mammals in Iceland (except for seals, whales, pets and livestock), and gives them protection status in 1994. The second pillar of

this law, conservation of wild birds and mammals, is defined as the banning of hunting and other actions by humans that reduce survival and/or recruitment rate of a species. This includes gathering of eggs from wild birds that are completely or temporarily protected. The third pillar of law no. 64/1994, hunting of wild bird and wild mammals, is summarized as the capturing or killing of wild animals including the gathering of wild bird's eggs.

The first two pillars of law no. 64/1994, protection and conservation, apply to both hunted and non-hunted wild animals. This legislation clearly states that it does not imply that a protected species is not allowed to be hunted anymore. Moreover, all protected species have the same rights regardless if they are hunted or not (Schmalensee et al., 2013). According to Icelandic law almost every terrestrial and marine species is allowed to be hunted, except for walrus (*Odobenus rosmarus*) (Alþingi, 2013b). This is not surprising because the hunting regulations on protected species evolved historically with legislations on the utilization of wild species or the prevention of damages they cause (Schmalensee et al., 2013). Consequently, law no. 64/1994 gives general provisions on how certain protected species have to be treated relative to hunting. The implementation of law 64/1994 also represents a major change in the hunting regulations since it marks the beginning of having to get an annual hunting license (veiðikort). This hunting license requires hunters to have certain amount of education and deliver a detailed report of their annual kill (Schmalensee et al., 2013).

In addition to law no. 64/1994, Iceland passed in 1996 the law no. 93/1996 on the conservation of nature (Alþingi, 1996), which intended to clarify the relationship between nature and man. The purpose of this new law is to promote the protection and utilization of resources based on sustainability. Although law no. 93/1996 aimed to foster sustainable development practices, it was similar to prior legislations, particularly with the 1956 law no. 48/1956 (Alþingi, 1999). Therefore, in 1999 the Icelandic parliament stipulated the new Nature Conservation Act (no. 44/1999) (Alþingi, 2012). The main driving force behind implementing this new law was that law no. 93/1996 only had little or no connection with other existing laws dealing with the interaction of man and nature (e.g., the Protection and Hunting of Wild Species Act no 64/1994, or law. no. 57/1998 on the exploration and exploitation of resources on the ground) (Alþingi, 1999). Also, in order to take into account the changing attitude in Iceland of recognizing the value of nature and the importance of a healthy environment, the new law no. 44/1999 aimed to integrate and connect existing legislations. Specifically, this law deals primarily with the formulation of responsibilities and procedures of conservation actions in Iceland. Hence, it refers to other laws, if necessary, to clarify which legislation addresses specific issues concerning nature conservation. For example, it clearly states in article 2 (Alþingi, 2012) that the Nature Conservation Act does in no way affect the provisions of law no. 64/1994. Given this, law no. 64/1994 and its regulations provide further information on conservation actions, especially about hunting guidelines for specific species in Iceland (Alþingi, 1993).

As for the arctic fox, article 12 of law 64/1994 solely refers to the provision regarding the species in Iceland. According to article 12 (§1) it is forbidden to destroy arctic fox dens and provoke disturbances during the breeding season (grenjatíma: 01 May until 31 July). Although the first paragraph seems to be in the interest of the arctic fox, Schmalensee et al. (2013) point out that the provision is intended to mainly prevent foxes from using other unknown den, since den locations are mostly used and known by hunters for hundreds of years, thus facilitating fox hunting. Furthermore, article 12 (§2) deals mainly with the allocation of responsibilities on the hunting of arctic foxes to the different legal institutions

in Iceland. It states clearly that foxes are allowed to be hunted when livestock is threatened without omitting article 6 of the law, which refers to the protection of all wild species in Iceland, if not stated otherwise. These provisions are also supported by article 7 of the law, where the protection of a certain species should be ensured as long as it is not meant for utilization or it causes damage. Further, it has to be mentioned that the term conservation never fully came to act on the arctic fox in Iceland, and that the protection of the species mainly consisted of the ban on hunting in nature reserves and national parks. The protection of the foxes is restricted to these areas mainly because of another important term of the same law 'damage caused by wild animals' (tjón af völdum villtra dýra), which represents the mainstay of the arguments of releasing the protection of the arctic fox and commercially hunt them. The 'damage caused by wild animals' has never been evaluated so it remains of unknown value.

Supplementary to law no. 64/1994, Iceland's parliament implemented the new regulation no. 437/1995 in 1995 (Reglugerðasafn, 2014) on the hunting of foxes and minks. With this regulation, the arctic fox received accidentally total protection in 26 areas in Iceland (e.g. nature reserves and national parks), where a year round hunting ban of all species was stipulated for all these areas. Although, all of these 26 protected areas were already established long before the development of the regulation no. 437/1995, it was the first time that a ban on hunting in these areas was formulated (Hersteinsson et al., 1989). The regulation also identified 28 areas, where hunting foxes and minks was of utmost important and, hence, mandatory to prevent damages. Furthermore, it revoked the protection of arctic foxes to prevent or reduce damage caused by the species from 01 August to 30 May in order to give hunting a legal status during this time period, except in the 26 protected areas mentioned previously. Moreover, special exceptions for landowners (hlunnindanýting) were stipulated, allowing them to prevent damages to their livestock by hunting foxes at any time of the year without actual proof of damage, i.e., it is enough to know that foxes are present in areas where livestock occur. Additionally, the regulation points out that this exception also applies to paid hunters if an immediate threat is present (Environment Agency of Iceland, 2006). Nonetheless, fox hunting under these special circumstances is only allowed with the approval of the Minister for the Environment and Natural Resources. This required approval is due to the provision of law no. 64/1994 and its quintessence, which states that the hunting of a certain species is only allowed if the health of the population is not at risk.

Although the regulations for the native arctic fox are sometimes with those for the introduced mink, it is stated that the mink, in contrast to foxes, is an invasive species and can be hunted all year round including in protected areas (Reglugerðasafn, 2014). Consequently, it can be interpreted that the change in 1994 led to a shift of not considering any longer the arctic fox as a vermin in Iceland. This in turn accounts for the difference of aiming to eradicate the arctic fox to finally preserving it. Furthermore, minks are not protected under law no. 64/1994. The species is regarded as a vermin in Iceland because of its introduction to Iceland due to fur-farming, which accidentally led to the escape of some individuals. Having had both species in the same regulation accounts for the historical background of Iceland and its relationship towards these two mammals. Hitherto, it is acknowledged that the arctic fox is a native species and that the national population has to be protected. In contrast, the mink is listed as an invasive species and is the subject of various action plans such as the North European and Baltic Network on Invasive Alien Species (NOBANIS) (Birnbaum, 2013). Nonetheless, it has to be stated that in general it is

the local authorities that are responsible for the majority of fox and mink hunting in Iceland. These parties most likely treat the two species equally since the management is mainly based on financial budget but not biology or scientific information.

2.3 International obligations

Iceland is actively involved in various international and global initiatives (Ministry for the Environment and Natural Resources, 2015). The country has agreed to sign and ratify several international treaties regarding environmental issues including the CBD, the Bern Convention, the Convention on Wetlands of International Importance, especially the Waterfowl Habitat (Ramsar Convention), and the Paris Convention. The two main agreements that account for the change in Icelandic legislations regarding arctic fox management are the Bern Convention and the CBD, which entered into force on 01 October and 11 December 1994, respectively. With the implementation of laws no. 64/1994 (Alþingi, 2013b) and no. 44/1999 (Alþingi, 2012) Iceland aimed to follow its obligations after ratifying these two international commitments, as well as to take into account the general change in Icelandic perception towards nature. Hence, the ratification of both conventions and the implementation of both laws represent Iceland's major shift towards a greater environmental consciousness in the 1990s.

The Rio Summit in 1992 highlighted the dramatic loss of biodiversity and the relationship between the long-term socio-economic well-being of humans and environmental protection (Secretariat of the Convention on Biological Diversity, 2005). One of the outcomes of the Rio Summit was the CBD, with an overall objective to conserve biodiversity, as well as to contribute to sustainable development (Secretariat of the Convention on Biological Diversity, 2005). The latter suggests that conserving biodiversity also focuses on ensuring its future use for humans. The CBD's provisions are to contribute to the conservation and sustainable use of biodiversity through planning and legislation, and to increase research and monitoring of biodiversity (Ministry for the Environment and Natural Resources, 2015). These CBD provisions, as well as those from the Ramsar and Bern Conventions, were essential for Iceland to stipulate the new Nature Conservation Act (no. 44/1999) (Alþingi, 1999).

Given that the CBD and law no. 44/1999 account for more general provisions on biodiversity and nature conservation, the ratification of the Bern and Paris Conventions, which were implemented through law 64/1994, had a greater impact in bringing about changes in arctic fox management in Iceland. The main effect of ratifying the Bern Convention was the listing of the arctic fox under Appendix II of this convention. Appendix II includes strictly protected fauna, especially endangered and endemic species, in all countries that agree to ratify the convention (Council of Europe, 1979), which led to the protection of the arctic fox in Iceland. Article 6 of the Bern Convention defines further what is prohibited for these protected species, e.g., the destruction of breeding sites and the disturbance of the species especially during the breeding season (Council of Europe, 1979). These prohibitions were successfully implemented into the Icelandic legislation through the Protection and Hunting of Wild Species Act (no. 64/1994) and its supplementary regulation no. 437/1995.

Table 2.1 Legislation changes from 930 to 2013 regarding the management of arctic foxes in Iceland

Year	Legislative change
1295	Implementation of the fox tax (dýratollur)
1789	Royal directive offering a prize to anyone inventing a fox trap
1792	New regulation on den hunting (grenjaleitir) in Borgarfjarðarsýslu
1808	Royal decree involving more regulations on how to hunt foxes, wages to fox hunters, and fines for farmers not fulfilling their hunting obligations
1834	Major changes to the royal decree of 1808. All farmers have to pay the fox tax (regardless if they hunt foxes or not). Both farmers hunting dens and fox hunters are to be paid with monies collected from the fox tax
1890	Expenditures for fox hunting to be paid from fox tax and district funds
1949	Implementation of law no. 56/1949 on the eradication of the arctic fox and the mink (fox poisoning required every third year)
1955	Implementation of law no. 10/1955 (i.e., amendment of law no. 56/1949), which stipulates that poisoning foxes (and minks) is a yearly obligation for property owners
1957	Implementation of law no. 52/1957, which leads to a new organization of the hunting efforts, and brings forward the most successful fox extermination effort recorded in Iceland (arctic fox population reduced to 1,000-1,300 individuals)
1964/69	Amendments no. 9/1964 and no. 43/1969 to law no. 52/1957 stop the poisoning of foxes due to severe effects on the white-tailed eagle population
1994	Implementation of the Protection and Hunting of Wild Species Act (no. 64/1994), which grants the arctic fox its first ever protected status in Iceland. Hunting still conducted on behalf of the authorities
1994	Ratification of the Convention on Biological Diversity (CBD) and the Bern Convention
1995	New regulation no. 437/1995 on the hunting of foxes and minks bans the hunting of all species, including the arctic fox, in 26 protected areas in Iceland
1996	Implementation of law no. 93/1996 on the conservation of nature
1997	Change in fox management encouraging winter hunting, which results in an increase of carcasses (baits) at fox hunting sites
1999	Implementation of the Nature Conservation Act (no. 44/1999)
2013	New Nature Conservation Act (no. 60/2013) restates that it does not affect the provisions of law no. 64/1994

Further obligations of the Bern Convention include not only the protection of species, but also their natural habitats. This obligation to protect natural habitats led to the development of a framework to implement a network of Areas of Special Conservation Interest

(Emerald Network) by the Council of Europe. Also, it led to the EU Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora (Natura 2000 Network), making it one of the most important contributions of the European Union (EU) towards the protection of biodiversity (Ministry for the Environment and Natural Resources, 2011). Iceland has not implemented this comprehensive network. However, the Bern Convention together with article 8 of the CBD, which also promotes in situ conservation by establishing a system of protected areas to protect natural habitats, has given Iceland the motivation to ban the hunting of all species, including the arctic fox, in 26 protected areas in order to protect its native wild fauna. Although all of these areas were protected by law prior to 1994, it was not until the Protection and Hunting of Wild Species Act (no. 64/1994) in 1994 that these areas were mentioned explicitly regarding the arctic fox and the hunting regulations.

In brief, it can be summarized that these international obligations led to significant changes in Iceland's legislations. By providing guidelines to implement these obligations into national legislations, the ratified conventions contributed to the evolution of Iceland's environmental laws and its perception of nature. Furthermore, the establishment of the Ministry for the Environment and Natural Resources in 1990 was an important catalyst to help implement these obligations and promote nature protection.

2.4 Planned improvements of current legislations

As mentioned previously, the 1990s ushered major changes in Iceland's environmental laws and also brought an increase in awareness of the role of nature in human well-being (Ministry for the Environment and Natural Resources, 2011). In addition, Iceland's responsibility to implement its international obligations became a prevailing issue since the existing legislations dealing with nature conservation were rather unclear and unsystematic (Ministry for the Environment and Natural Resources, 2011). Although minor changes were made to the legislations after 1999, the Icelandic parliament in accordance with the Minister of Environment and Natural Resources decided in 2009 to review the laws on nature conservation. This review took 2 years and was published in 2011 as the 'Nature Protection: White Book about legislations to protect the nature of Iceland' (Ministry for the Environment and Natural Resources, 2011). The main goal of the review was to provide recommendations for future legislations in Iceland. As a result, the White Book built the foundation for the new law on nature conservation no. 60/2013 (Alþingi, 2013a), which came into force on 1 July 2015.

The White Book clearly states that it does not provide recommendations for the protection, conservation and hunting of wild birds and mammals because another working group was established to review the Protection and Hunting of Wild Species Act (no. 64/1994) (Ministry for the Environment and Natural Resources, 2011). Consequently, the new law no. 60/2013 restates, as its older version of 1999, that it does not affect the provisions of law no. 64/1994. The working group, namely Schmalensee et al. (2013), reviewing law no. 64/1994 published a report in 2013, which adopted many recommendations from the first review on fox management policies in 2004 (Ministry for the Environment and Natural Resources, 2004) by stating that law no. 64/1994 focuses primarily on hunting rather than protecting and conserving species (Schmalensee et al., 2013). They identified the need to

give greater priority to the other two pillars of this legislation (i.e., protection and conservation). Furthermore, the working group highlighted that the law should not exclude species and any new legislation should apply to all wild birds and mammals of Iceland, including seals and whales (Schmalensee et al., 2013).

Another recommendation from the working group was to change the name of the law from ‘protection, conservation and hunting’ to ‘protection, well-being and hunting’ because it better represents the actual intention of the legislation (Schmalensee et al., 2013). This prevents misconceptions about the definition of conservation in the law, which refers to a ban on hunting or any other actions by humans that cause harm to the species or decrease its well-being. According to Schmalensee et al. (2013), the conservation of nature in Iceland has been defined as the protection of nature against human actions. This goes hand in hand with the protection of wild animals against human activities. However, the main focus of the second pillar of law no. 64/1994 is on the well-being of species rather than strict conservation, the latter which implements a ban on hunting and other human actions. Therefore, Schmalensee et al. (2013) point out that the well-being of all wild birds and wild mammals should be a guiding principle for Iceland regarding its fauna. Also, they recommend that to improve the legal status of wildlife, the concept of well-being should include the right to be free from human actions that cause (1) thirst, hunger and nutritional deficiencies, (2) discomfort in their environment, (3) fear and stress, (4) pain and diseases, and (5) inhibit their natural behaviour.

In terms of the arctic fox, the report agrees with article 12 of law 64/1994 which deals with this species. Nonetheless, they argue that the management of fox hunting around Iceland needs to be improved. Moreover, Schmalensee et al. (2013) highlight the need to define and properly assess fox predation. Given that the arctic fox is native to Iceland there has to be a clear distinction between natural predation and actual damage to livestock (Schmalensee et al., 2013). In addition, an evaluation of the effectiveness of fox hunting in reducing damages to livestock is lacking but essential. Such evaluation will help the Minister of Environment and Natural Resources to decide where fox hunting is most likely to reduce losses to livestock (Schmalensee et al., 2013). This is the key factor in releasing the hunting ban on the species and obliges municipalities to conduct a costly foxhunting on the base of potential but unknown damage. Indeed, since the onset on the law of protection (64/1994) until 2012, 84,000 foxes were killed, costing the authorities 1.6 billion ISK on the price of December 2012 (Unnsteinsdóttir, 2013). The latest review on arctic fox management policies was published in 2014 by the Environment Agency of Iceland (Environment Agency of Iceland, 2014) and so far none of the recommendations mentioned above have been implemented into new legislation.

2.5 Conclusion

The arctic fox is a key species in Arctic habitats and ecosystems. With its high potential to adapt to different conditions, it is characterized as a generalist species with a circumpolar distribution. In contrast to the endangered arctic fox population in Fennoscandia, due to overharvesting in the first half of the 20th century (Angerbjörn et al., 2004), Iceland’s arctic fox population is considered viable and not threatened. Nonetheless, recent research shows that population numbers in Iceland have declined for the first time in 30 years (Unnsteinsdóttir, 2014). Although the species is Iceland’s only native terrestrial mammal,

it does not have a management plan to ensure its long-term survival in the country. The fact that 99% of the remaining arctic fox population in Europe resides in Iceland (Schmalensee et al., 2013), it gives this country a distinct global responsibility to preserve its arctic fox population. Furthermore, the Icelandic population has been isolated for a long time (Dalén et al., 2005; Geffen et al., 2007) and has shown several adaptations to environmental changes that other arctic fox populations will face in the future (Hersteinsson, 1984; Hersteinsson et al., 1989). Therefore, the Icelandic arctic fox will play an important role in predicting future maintenance of viable populations within the species' circumpolar range.

Examining current Icelandic legislations regarding the protection and hunting of arctic foxes, shows that Iceland has protected this species with the aim to guarantee it will not become endangered in the country (Alþingi, 2013b). However, it is apparent that the main scope of the legislation is the hunting of arctic foxes. The revision report by Schmalensee et al. (2013) rightly states that much more emphasis has to be placed on the protection and well-being of the species. Presently, Iceland maintains its centuries-old bounty system to prevent damage to livestock without fully complementing it with up-to-date scientific research, monitoring and management of the species. Moreover, there is an important data gap on the extent and economic impacts of arctic fox predation on livestock in Iceland. A lack of a clear understanding of the interaction of arctic foxes and livestock hinders the development of management actions to protect arctic foxes and manage any conflicts with livestock. Similarly, there is uncertainty about how current hunting practices affect the arctic fox population in Iceland. Indeed, the arctic fox population has been shown to have declined and increased in a 40 year time period, despite steady hunting effort (Icelandic Institute of Natural History, 2014). Still many important data gaps need to be addressed in order to implement effective and sustainable conservation actions in the future.

Another important step was to change the regulation for hunting of arctic foxes and minks. Given that the status of the arctic fox as a vermin has changed with the legislations of the 1990s, it was obviously necessary to have separate regulation for hunting this species. Today, a special working group, on the behalf of the Ministry for the Environment and Natural Resources, works on improvement and update of the law nr. 64/1994 and the legislations that are related to the issue.

As for the international commitments, the Bern Convention had the highest impact on national legislations regarding the arctic fox population in Iceland. The convention lists the arctic fox under Appendix II for strictly protected species, which prohibits any capturing, keeping, or killing of listed species. However, Iceland stipulated its legislation for the arctic fox as if this species was listed under Appendix III of the Bern Convention, which refers to protected species that are allowed to be hunted without compromising their long-term viability. In order to take into account the historical background of Iceland's fox hunting tradition and eliminate legislative confusion, Iceland's current national legislations derived from stipulating a reservation for the arctic fox population in accordance with article 21 (§1) of the Bern Convention, which allows contracting parties to 'specify the territory or territories to which this Convention shall apply' (Council of Europe, 1979).

The Bern Convention, together with the CBD, requires the establishment of in situ conservation sites. The existing 26 protected areas in Iceland with a total ban on hunting provide the first step towards a comprehensive network of protected areas in the country. However, a lack of an overall strategy for this network makes it difficult to assess whether

or not the existing protected areas are sufficient for the long-term viability of the arctic fox population. Currently, it is likely that most of these protected areas are too small and isolated to represent an inclusive and effective network suitable for the arctic fox population in Iceland (Ester Unnsteinsdóttir, pers. comm.). It is essential to adapt this network to encompass the ecological requirements of arctic foxes in Iceland. For example, to include both habitat types (coastal and inland) used by arctic foxes (Pálsson et al., 2015 in prep.) in the planning of protected areas and corridors. Population estimates and demographic studies are based on collaboration between hunters and scientists. Continuous monitoring on the population dynamics is essential in order to detect any signs of changes in population rates and life history traits. Furthermore, to ensure the development of an effective network it is also important to continue studying the genetic diversity of arctic foxes throughout Iceland and determine if differences exist among regions (see Norén et al., 2009). Similarly, a better understanding of arctic fox migration patterns is needed to address uncertainties about their movement within the country, and if it varies with age, breeding status, sex, region and/or season. Information on the population's genetic diversity and migration will help identify other potential areas to protect, as well as facilitate assessing the interaction of arctic foxes with livestock. Management has to be based on knowledge on the social system and its role as a limiting factor on breeding abilities, dispersal and genetic diversity. Long-term comparative studies on population regulation in protected and non-protected areas are therefore important to understand the factors that affect breeding success and mortality rate.

The implementation of international and national obligations regarding environmental issues provides a great opportunity for Iceland to foster its leadership on the international stage. Given climate change and overexploitation of natural resources worldwide, it would be beneficial for Iceland to continue adapting its national strategy to further protect the country's unique and diverse environment and natural resources. Although major changes have already been made to preserve Icelandic biodiversity, more are needed. This study has shown that Iceland has both the responsibility and opportunity to be a leader and a pioneer in protecting the arctic fox, ensuring the species long-term survival. The decline of the Fennoscandian arctic fox population and the great efforts that Sweden, Norway, and Finland have invested for several decades to the recovery of this species is a cautionary tale of the drawback to a reactive conservation approach. Embracing a proactive and preventative conservation strategy to preserve Iceland's biodiversity will not only have ecological, but also socio-economic benefits in the long run.

2.6 References

- ACIA, 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge.
- Alþingi, 2013a. Lög um náttúruvernd nr. 60/2013 [e. Nature Conservation Act no. 60/2013]. URL: <http://www.althingi.is/lagas/143b/2013060.html> (accessed 8.15.15).
- Alþingi, 2013b. Lög um vernd, friðun og veiðar á villtum fuglum og villtum spendýrum nr. 64/1994 [e. Protection and Hunting of Wild Species Act no. 64/1994]. URL: <http://www.althingi.is/lagas/143b/1994064.html> (accessed 8.20.15).

- Alþingi, 2012. Lög um náttúruvernd nr. 44/1999 [e. Nature Conservation Act no. 44/1999]. URL: <http://www.althingi.is/lagas/143b/1999044.html> (accessed 7.15.15).
- Alþingi, 1999. Frumvarp til laga um náttúruvernd, þskj. 848, 528. mál, 123. löggjafarþing [e. Parliamentary bill no. 848 - 528th issue to the Nature Conservation Act, 123th congress year]. URL: <http://www.althingi.is/altext/123/s/0848.html> (accessed 8.20.15).
- Alþingi, 1996. Lög um náttúruvernd nr. 93/1996 [e. Law on nature conservation no. 93/1996]. URL: <http://www.althingi.is/altext/120/s/1222.html> (accessed 8.15.15).
- Alþingi, 1993. Frumvarp til laga um vernd, friðun og veiðar á villtum fuglum og villtum spendýrum, 201. mál, 117. löggjafarþing [e. Parliamentary bill - 201th issue to the Protection and Hunting of Wild Species Act, 117th congress year]. URL: <http://www.althingi.is/altext/117/s/0223.html> (accessed 8.20.15).
- Alþingi, 1969. Lög um eyðingu refa og minka nr. 43/1969 [e. Law on the eradication of Arctic foxes and minks no. 43/1969]. URL: <http://www.althingi.is/altext/89/s/pdf/0559.pdf> (accessed 8.13.15).
- Alþingi, 1964. Lög um eyðingu refa og minka nr. 9/1964 [e. Law on the eradication of Arctic foxes and minks no. 9/1964]. URL: <http://www.althingi.is/altext/84/s/pdf/0278.pdf> (accessed 8.13.15).
- Alþingi, 1957. Lög um eyðingu refa og minka nr. 52/1957 [e. Law on the eradication of Arctic foxes and minks no. 52/1957]. URL: <http://althingi.is/altext/76/s/pdf/0660.pdf> (accessed 8.20.15).
- Alþingi, 1956. Lög um náttúruvernd nr. 48/1956 [e. Law on nature conservation no. 48/1956]. URL: <http://www.althingi.is/altext/75/s/pdf/0635.pdf> (accessed 8.20.15).
- Alþingi, 1955. Lög um eyðingu refa og minka nr. 10/1955 [e. Law on the eradication of Arctic foxes and minks no. 10/1955]. URL: <http://www.althingi.is/altext/74/s/pdf/0432.pdf> (accessed 8.12.15).
- Alþingi, 1949. Lög um eyðingu refa og minka nr. 56/1949 [e. Law on the eradication of Arctic foxes and minks no. 56/1949]. URL: <http://www.althingi.is/altext/68/s/pdf/0808.pdf> (accessed 8.20.15).
- Angerbjörn, A., Berteaux, D., Ims, R., 2012. Arctic Fox (*Vulpes lagopus*). URL: http://www.arctic.noaa.gov/report12/arctic_fox.html (accessed 7.15.15).
- Angerbjörn, A., Hersteinsson, P., Tannerfeldt, M., 2004. Europe and North and Central Asia (Palearctic): Arctic fox (*Alopex lagopus*), in: Sillero-Zubiri, C., Hoffmann, M., Macdonald, D.W. (Eds.), *Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan*. IUCN/SSC Canid Specialist Group. Gland, Switzerland and Cambridge, UK.
- Angerbjörn, A., Tannerfeldt, M., 2014. *Vulpes lagopus*. IUCN Red List Threat. Species. URL: www.iucnredlist.org (accessed 8.20.15).
- Audet, A.M., Robbins, C.B., Larivière, S., 2002. *Alopex lagopus*. *Mamm. Species* 1–10. doi:10.2307/3504336

- Birnbaum, C., 2013. NOBANIS - Invasive Alien Species Fact Sheet - Neovison vison. URL: www.nobanis.org, (accessed 7.20.15).
- Callaghan, T. V., Björn, L.O., Chernov, Y., Chapin, T., Christensen, T.R., Huntley, B., Ims, R.A., Johansson, M., Jolly, D., Jonasson, S., Matveyeva, N., Panikov, N., Oechel, W., Shaver, G., Elster, J., Henttonen, H., Laine, K., Taulavuori, K., Taulavuori, E., Zöckler, C., 2004. Biodiversity, Distributions and Adaptations of Arctic Species in the Context of Environmental Change. *AMBIO A J. Hum. Environ.* 33, 404–417. doi:10.1579/0044-7447-33.7.404
- Council of Europe, 1979. Bern Convention on the Conservation of European Wildlife and Natural Habitats.
- Dalén, L., Fuglei, E., Hersteinsson, P., Kapel, C.M.O., Roth, J.D., Samelius, G., Tannerfeldt, M., Angerbjörn, A., 2005. Population history and genetic structure of a circumpolar species: the arctic fox. *Biol. J. Linn. Soc.* 84, 79–89. doi:10.1111/j.1095-8312.2005.00415.x
- Dalén, L., Götherström, A., Tannerfeldt, M., Angerbjörn, A., 2002. Is the endangered Fennoscandian arctic fox (*Alopex lagopus*) population genetically isolated? *Biol. Conserv.* 105, 171–178. doi:10.1016/S0006-3207(01)00180-X
- Environment Agency of Iceland, 2014. Aætlun til þriggja ára um refaveiðar 2014-2016 [e. Arctic fox hunting plan for 3 years 2014-2016]. URL: http://www.ust.is/library/Skrar/Einstaklingar/Veidi/%C3%81%C3%A6tlun%20til%20%C3%BERiggja%20%C3%A1ra%20um%20refavei%C3%B0ar%202014_2016.pdf (accessed 9.23.15).
- Environment Agency of Iceland, 2006. Upplýsingar og staðreyndir - Refa- og minkaveiði [e. Information and facts - Hunting of arctic foxes and minks].
- Frankham, R., 1997. Do island populations have less genetic variation than mainland populations? *Heredity (Edinb)*. 78 (Pt 3), 311–327. doi:10.1038/sj.hdy.6880980
- Fuglei, E., Ims, R.A., 2008. Global warming and effects on the arctic fox. *Sci. Prog.* 91, 175–191.
- Geffen, E.L.I., Waidyaratne, S., Dalén, L., Angerbjörn, A., Vila, C., Hersteinsson, P., Fuglei, E., White, P.A., Goltsman, M., Kapel, C.M.O., 2007. Sea ice occurrence predicts genetic isolation in the Arctic fox. *Mol. Ecol.* 16, 4241–4255.
- Gilg, O., Sittler, B., Hanski, I., 2009. Climate change and cyclic predator–prey population dynamics in the high Arctic. *Glob. Chang. Biol.* 15, 2634–2652. doi:10.1111/j.1365-2486.2009.01927.x
- Hersteinsson, P., 2006. Íslenski tófustofninn [e. The Icelandic Arctic fox population], in: *Veiðidagbók 2006*. The Environment Agency of Iceland, Reykjavík, pp. 6–15.
- Hersteinsson, P., 1984. The behavioural ecology of the Arctic fox (*Alopex lagopus*) in Iceland. D.Phil., Oxford University. 286 pp.
- Hersteinsson, P., 1980. Refir [e. Arctic Foxes], in: Einarsson, Á. (Ed.), *Villt spendýr. Rit Landverndar*.

- Hersteinsson, P., Angerbjörn, A., Frafjord, K., Kaikusalo, A., 1989. The arctic fox in fennoscandia and Iceland: Management problems. *Biol. Conserv.* 49, 67–81. doi:10.1016/0006-3207(89)90113-4
- Icelandic Institute of Natural History, 2014. Íslenski refastofninn á niðurleið [e. Decline of the Icelandic arctic fox population]. URL: http://www.ni.is/media/dyrafraedi/spendyr/Stofnmat-a-refum_oktober-2014.pdf (accessed 9.23.15)
- IUCN, 2009a. Species and climate change: More than just the Polar Bear. URL: <https://portals.iucn.org/library/sites/library/files/documents/2009-051.pdf> (accessed 8.20.15).
- IUCN, 2009b. Arctic foxes and climate change: Out-foxed by Arctic warming. URL: http://cmsdata.iucn.org/downloads/fact_sheet_red_list_arctic_foxes.pdf (accessed 8.20.15).
- Mellows, A., Barnett, R., Dalén, L., Sandoval-Castellanos, E., Linderholm, A., McGovern, T.H., Church, M.J., Larson, G., 2012. The impact of past climate change on genetic variation and population connectivity in the Icelandic arctic fox. doi:10.1098/rspb.2012.1796
- Mills, L.S., Soulé, M.E., Doak, D.F., 1993. The Keystone-Species Concept in Ecology and Conservation. *Bioscience* 43, 219–224. doi:10.2307/1312122
- Ministry for the Environment and Natural Resources, 2015. International co-operation [e. Alþjóðlegt samstarf]. URL: <http://www.umhverfisraduneyti.is/althjodlegt-samstarf/>
- Ministry for the Environment and Natural Resources, 2011. Náttúruvernd: Hvítbók um löggjöf til verndar náttúru Íslands [e. Nature Protection: Whitebook about legislations to protect the nature of Iceland]. Reykjavík.
- Ministry for the Environment and Natural Resources, 2004. Nefnd um áhrif refs í íslenski náttúru: Skýrsla og tillögur nefndar [e. Committee for the effects of the arctic fox in Icelandic natur: Report and suggestions of the Committee]. URL: <http://www.umhverfisraduneyti.is/utgefid-efni/nr/635>
- Norén, K., Angerbjörn, A., Hersteinsson, P., 2009. Population structure in an isolated Arctic fox, *Vulpes lagopus*, population: the impact of geographical barriers. *Biol. J. Linn. Soc.* 97, 18–26. doi:10.1111/j.1095-8312.2009.01172.x
- Reglugerðasafn, 2014. Reglugerð um refa- og minkaveiðar nr. 437/1995 [e. Regulation on the hunting of Arctic foxes and minks no. 437/1995]. URL: <http://www.reglugerd.is/reglugerdir/eftir-raduneytum/umhverfisraduneyti/nr/4354> (accessed 8.20.15).
- Schmalensee, M. von, Skarphéðinsson, K.H., Vésteinsdóttir, H., Gunnarsson, T.G., Hersteinsson, P., Arnþórsdóttir, A.L., Arnardóttir, H., Hauksson, S.B., 2013. Vernd, velferð og veiðar villtra fugla og spendýra [e. Protection, welfare and hunting of wild bild and mammals]. Lagaleg og stjórnsýsluleg staða og tillögur um úrbætur. Skýrsla unnin fyrir umhverfis- og auðlindaráðherra.

Scholander, P.F., Hock, R., Walters, V., Irving, L., 1950. Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation, and basal metabolic rate. *Biol. Bull.* 99, 259–271.

Secretariat of the Convention on Biological Diversity, 2005. *Handbook of the Convention on Biological Diversity Including its Cartagena Protocol on Biosafety*, 3rd edition. Montreal, Canada.

Strand, O., Stacy, J.E., Wiadaryatne, N.S., Mjølnerød, I.B., Jakobsen, K., 1998. Genetisk variasjon i små Fjellrevbestander [e. Genetic variation in small Arctic fox populations], in: Kvam, T., Jonsson, B. (Eds.), *Store Rovdyrs Ekologi I Norge* Trondheim. pp. 65–69.

Unnsteinsdóttir, E.R., 2014. Decrease in Icelandic Arctic Fox Population. URL: http://www.melrakki.is/news/Decrease_in_Icelandic_Arctic_Fox_Population/ (accessed 8.20.15).

Unnsteinsdóttir, E.R., 2013. The fox tax - a brief overview of Conservation and Management of Arctic foxes in Iceland. Presentation presented at the 4th International Conference in Arctic Fox Biology, Hotel Nupur, IC.

3 Comparison of arctic fox management in Iceland and Svalbard

3.1 Introduction

The implementation process of integrating international obligations into national legislations requires a joint effort on the part of both the transnational community and the domestic agencies in each country. By voluntarily ratifying international agreements, each contracting party acknowledges the responsibility to develop a legal framework that ensures the alignment of national legislations and policies with international provisions. The loss of biodiversity is recognized as a transboundary issue that needs to be faced by a collective global effort (De Klemm and Shine, 1993). Hence, numerous multilateral treaties have emerged on the international stage that focus on the protection of biodiversity. However, the successful implementation of international environmental commitments, such as those tackling the loss of biodiversity, is complex and can differ between national states (Victor, 1998). Consequently, it is important to follow the development of national laws and regulations in order to support an effective implementation process of international commitments.

Iceland and Norway represent two Nordic countries that are highly involved in various international environmental treaties and initiatives. Because of their efforts to implement international provisions into national legislations, they provide a good example of how the implementation process has influenced national approaches to protect the environment within their national sovereignty. In order to show differences and similarities of how international commitments shaped the legislative body in Iceland and Norway, this study aims to compare national legislative changes regarding the arctic fox (*Vulpes lagopus*) management in these two countries. This comparison will help illustrate how broader international legislations and agreements shape specific national laws and management of a species. Furthermore, in order to have a more complete assessment of different implementation processes, this study focuses on the arctic fox populations of Iceland and Svalbard (Norway) because they share similarities. For example, both Iceland and Svalbard represent islands in the North Atlantic with thriving arctic fox populations. Given the endangered status of the arctic fox population in Fennoscandia, the populations in Iceland and Svalbard are important sanctuaries for the species. Moreover, they highlight the valuable role of island populations in ensuring the long-term survival of the species on a global scale. In addition, the management regimes of the arctic fox in Iceland and Svalbard demonstrate that the inclusion of cultural heritage, i.e., hunting of the species, and a current conservation approaches to protect the species do not have to be at odds with each other. The comparison of these two island populations will provide a much needed insight into the development of environment protection and management of arctic foxes.

To accomplish the balancing act of integrating cultural heritage and prevailing environmental interests into national policies requires an adequate understanding of the different perspectives. The main objective of this study is to use the knowledge gained from the comparison between Iceland and Svalbard's arctic fox management regimes to provide recommendations to improve existing efforts. By systematically examining the international and legislative body as well as the management actions of Iceland and Svalbard, these recommendations will help develop a presently missing management plan that ensures a healthy and self-sustaining arctic fox population in Iceland. Furthermore, these recommendations will be based on the current ecological status of arctic foxes in Iceland targeting legislation and management actions to ensure the long-term survival of the species in Iceland.

3.2 Arctic fox management in Iceland and Svalbard

Iceland has undergone major changes in its environmental legislations since the ratification of the Convention of Biological Diversity (CBD) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) in the 1990s. For example, with the stipulation of the Protection and Hunting of Wild Species Act in 1994 (Alþingi, 2013b) and the Nature Conservation Act in 1999 (Alþingi, 2012), Iceland's government aimed to implement the international provisions they agreed upon. A major accomplishment for Iceland in applying international environmental commitments into national legislations, was to no longer consider the arctic fox, its only native terrestrial mammal, a vermin species. The official recognition of the arctic fox as a protected species in 1994 represents the end of a long standing tradition in Iceland of trying to eradicate the arctic fox in order to prevent assumed damages to valuable livestock (Schmalensee et al., 2013). This tradition has been a part of Iceland's culture since the time of the early settlers (9th century) and symbolizes a strong part of Iceland's heritage (Hersteinsson, 1980). Hence, it is understandable that changes in the legislative body have to evolve over time in order to reshape the public's perception of the arctic fox and to provide effective management actions that ensure both the acknowledgment of cultural needs and the long-term survival of the species. At present, Iceland has no Red List for its terrestrial mammals because none of them are at risk of extinction. Hence, it is important that future management actions aim to maintain this thriving arctic fox population in the country.

Similarly, Svalbard's environmental policies undergone major changes in the last decades. With the ratification of the CBD in the 1990s, Norway has followed up its responsibility to conserve the country's biodiversity by, *inter alia*, prioritizing the Arctic region because of its untouched wilderness character (Ministry of Climate and Environment, 1998). Hence, Svalbard's importance as an area with sound environmental protection was especially highlighted by developing the goal to establish Svalbard as one of the best managed wilderness areas in the world (St. meld. nr. 22, 1994-95, St. meld. nr. 9, 1999-2000). This overarching aim was manifested with the stipulation of the Svalbard Environmental Protection Act in 2002 and its update in 2012 (Ministry of Climate and Environment, 2012). The changes in the 1990s involved that the arctic fox in Svalbard gained the status of a priority species (Fuglei et al., 1998), which led to a controlled hunting regime and improved scientific research on the archipelago. Currently, the species is classified as 'Least Concern' on Svalbard by the Norwegian Red List for Species (Norwegian

Biodiversity Information Centre, 2010b) and its population is considered to be viable and stable. Furthermore, arctic foxes are only allowed to be hunted in six designated small areas on Spitsbergen, the main island of Svalbard.

The comparison of the arctic fox management of both islands shows that Icelandic and Norwegian authorities have issued major changes since the 1990s. One of the main driving forces behind this development is the growing concern for the loss of biodiversity worldwide and the acknowledgment of its importance to people's socio-economic well-being (Secretariat of the Convention on Biological Diversity, 2005). The ratification of the CBD by Iceland and Norway in 1993 and 1994, respectively, represents an important milestone in advancing the environmental policies in these countries. Furthermore, Iceland agreed to the Bern Convention in 1994, while Norway has been a party to this convention since 1979. The ratification of both conventions by Iceland led to the major change of granting protection status to its arctic fox population in 1994. The protection of this species integrated the long hunting tradition in Iceland, where the protection status was understood as the guarantee to ensure the long-term well-being of the species without omitting the right to hunt arctic foxes in the country (Schmalensee et al., 2013). This legislative status for the arctic fox in Iceland would have not been fully in line with the provision of the Bern Convention, which lists the arctic fox under Appendix II. The appendix includes strictly protected animals that are not allowed to be captured, kept, or killed (Council of Europe, 1979). Therefore, Iceland revoked this contradiction before ratifying the convention by issuing a reservation for its arctic fox population regarding the Bern Convention according to article 21 (§1), that permits every contracting party to decide the scope of the convention for their country. Iceland thereby followed the example of Norway, which put forward the same reservation in 1986 to account for the differences of its arctic fox population in Svalbard relative to that of the mainland (St. prp. nr. 12, 1985-86). This significant change in Iceland and Svalbard's legislations reflects a positive development in aligning the national legislative body with international obligations regarding environmental laws.

The arctic fox in Svalbard can be seen as protected because it can only be hunted in six small areas in the entire archipelago (see Chapter 2). This differs to Iceland's approach in protecting the species, which bans the hunting of arctic foxes in 26 protected areas but allows their hunting in the rest of the country (see Chapter 1). Furthermore, the hunting period varies between Svalbard and Iceland. The hunting period for arctic foxes in Svalbard is from 01 November until 15 March, whereas in Iceland the hunting season is shorter and is only from 01 June to 31 July. Also contrasting to Svalbard's provisions, which have no exception to hunting arctic foxes outside the specified time frame, Iceland allows the hunting of arctic foxes during the non-hunting period (01 November to 30 May) if there is a potential threat to livestock. This, of course, represents a reasonable factor for Iceland's farmers since livestock are economically important to Iceland, whereas commercial farming does not exist in Svalbard and is, hence, of no concern. It further shows the difference of Iceland's hunting regime, which aims to keep the arctic fox population low to diminish the risk of potential damage to livestock. To accomplish this goal, Iceland's hunting regime is based on a bounty system, in which every hunter receives a financial incentive for every killed fox. In contrast, Svalbard's hunting regime is nowadays mostly based on recreational purposes. However, it should be noted that both hunting regimes are also part of monitoring the status of the arctic fox population. For example, it is the duty of hunters in Iceland and Svalbard to report hunting numbers to the

local authorities in order to ensure lower total numbers of arctic foxes (in Iceland) and to guarantee the long-term health of the species (in Svalbard). The hunting records show that 84,036 arctic foxes have been killed in Iceland from 1996 to 2012 (Unnsteinsdóttir, 2013) and 2,026 individuals in Svalbard from 1998 to 2014 (Norwegian Polar Institute, 2015).

The monitoring of two areas in West Svalbard (Brøggerhalvøya/Kongsfjorden and Adventdalen/Sassendalen) also complements the hunting data by providing information about population dynamics in these areas. In Iceland research on the population dynamics of arctic foxes has been conducted for nearly 40 years, and nationwide detailed bag-statistics have been collected since 1958. This long-term data set is only possible because of the support and cooperation of hunters throughout the whole country who voluntarily sent culled arctic foxes to researchers in Iceland. In addition to the examination of arctic fox carcasses, there is field-based monitoring in the Hornstrandir Nature Reserve (northwest Iceland) that looks at the impact of tourists on the denning behaviour of arctic foxes.

The comparison between Iceland and Svalbard shows that both management approaches are slightly different and can complement each other. The following sections will provide recommendations for Iceland's management scheme, while taking into account the national and historical background of Iceland and Svalbard's approaches in protecting their arctic fox populations.

3.3 Regulatory and legislative recommendations

Iceland is a committed partner of the international community regarding environmental issues by being part of several transnational and global initiatives (Ministry for the Environment and Natural Resources, 2015). With the signing and ratification of several international treaties, Iceland agreed to implement provisions in order to conserve the country's natural heritage. The change of national legislations concerning the arctic fox since 1994 is one example of the transformation of Iceland's national environmental legislations. The total ban of hunting of all species in 26 protected areas led to an indirect protection status of the arctic fox, which can be regarded as a major commitment towards international obligations. However, the arctic fox (as most other species in Iceland) and the majority of protected areas in the country are without a management plan. This indicates that an overall strategy for the species, as well as more comprehensive wilderness management, is still needed in Iceland. To account for the needs of the species and its cultural importance for Iceland, it is essential to promote further legislative developments in order to shape a framework that ensures the alignment of national legislations with international provisions. Since the arctic fox remains a species that is still part of a hunting regime in Iceland, the protection status has been defined as a protection against actions of humans, which threaten the long-term survival of the species (Alþingi, 2013b). Hence, Iceland's authorities classify hunting, if regulated, as no threat to the arctic fox population in Iceland. This view is mainly derived from a more or less sustainable arctic fox population in Iceland despite consistent hunting efforts for over 1000 years.

As for the national legislation regarding the protection of the arctic fox, the Protection and Hunting of Wild Species Act (no. 64/1994) and the regulation on the hunting of arctic foxes and minks (no. 437/1995) represent the main provisions that regulate the management of the species in Iceland. Firstly, in agreement with the recommendation of

the working group of Schmalensee et al. (2013), the Icelandic name of the Protection and Hunting of Wild Species Act (no. 64/1994) should be changed from ‘protection, conservation and hunting’ to ‘protection, well-being and hunting’. This change will avoid misconceptions since the law defined conservation as the ban of hunting or any other actions that cause harm to the species or decrease its well-being. Referring to a ban of hunting in this legislation should be avoided because hunting is, as mentioned previously, a strong part of Iceland’s culture and, consequently, the main focus of the current law. Although, the aim to prevent harm to a species or a decline of its well-being is meant as a guiding principle for the whole population and not for each individual, it is important to prevent potential contradictions in the legislation. Hence, it will be beneficial for the consistency of the law to switch the wording from a ban of hunting to the overarching goal of ensuring the general well-being of the species.

Secondly, to underline the changing perception of the arctic fox from a vermin to a protected species, it is important that the national regulation no. 437/1995 (Reglugerðasafn, 2014), dealing with the provision of arctic fox and mink (*Neovison vison*) hunting, be considered separately for each species. Having the native arctic fox and the introduced mink under the same regulation originates from the long tradition of considering both species as national pests. To end this persistent view and change it into perceiving the arctic fox as a valuable natural feature of Iceland’s environment, a working group has been established to develop two separate regulations for each species in order to distinguish between native and introduced species. The implementation of these two regulations will support the current laws that are already in the right path of incorporating this change of perception by clearly separating the legislative status of the arctic fox from the mink. Since it is important to reflect this significant change on all levels, having a separate regulation for the arctic fox would account for the species’ key role in Iceland’s environment, and generate another major step towards Iceland’s approach to preserve its own nature.

3.4 Management recommendations

The review of the Protection and Hunting of Wild Species Act (no. 64/1994) from 2013 pointed out that the legislation focuses mainly on the hunting of the arctic fox rather than its protection and conservation (Schmalensee et al., 2013). In order to account for international obligations, there is a need to focus both the legislative body and the actual management of the species on the long-term viability of the entire arctic fox population. Besides the recommended changes to the legislative body, there are also other management actions that can be implemented to increase the resilience of the arctic fox population both against humans induced pressures and natural changes. These management actions will help foster a proactive conservation approach, allowing hunting efforts to be based on their effects on arctic foxes. Hunting, when regulated and managed properly, can be a valuable tool to monitor the health of the arctic fox population and support scientific research. However, without a comprehensive hunting strategy, it generates uncertainty and risk on the long-term survival of the species. The following recommendations provide additional steps to manage more effectively the arctic fox in Iceland.

3.4.1 Examination of damage to livestock

An important question to address in order to establish an effective management plan for the arctic fox in Iceland, is how much damage does the arctic fox cause to livestock? The

damage to livestock is one of the main reasons for the long tradition of hunting arctic foxes in Iceland, and is a central issue in maintaining the current hunting actions. Given that approximately 100 million Icelandic Kronas (ISK) are spent yearly in hunting arctic foxes (Unnsteinsdóttir, 2013), having a clear understanding of the impacts of this species to livestock will also help allocate limited financial resources. A study conducted almost 20 years ago found little evidence of damages to healthy livestock by arctic foxes (Hersteinsson and Macdonald, 1996). This study investigated arctic fox dens in Iceland and showed that only 19,4% of the fox dens studied (1125 in total) had lamb carcasses, and of these 44% were a single carcass (Hersteinsson and Macdonald, 1996). A more recent study points out that lamb mortality in Iceland (2,8%) can be considered low in comparison to that seen in Norway (8,9%) (Helgason et al., 2013). Furthermore, lamb mortality only increased non-significantly from 2000 to 2011, despite an increase in the arctic fox population during the same period in Iceland (Helgason et al., 2013). Consequently, the study concluded that the impact of arctic foxes on lamb mortality has to be further investigated in order to determine the degree of damage to valuable livestock. Nonetheless, this research represents an important step towards a comprehensive hunting management that puts the damage to livestock in context to the actual density of arctic foxes and the effectiveness of current hunting actions. At present, the extent of the economic damages to farmers is not known and it is unclear whether or not these damages are different between regions in Iceland. Once this knowledge is gained, it will be possible to identify potential hotspots of damages and evaluate if current hunting efforts overlap with them. In addition, research could start assessing how these damages are connected to arctic fox abundance and population dynamics. Hence, evaluating the damage to livestock can be an important part of the arctic fox management, helping to adjust hunting efforts as needed to increase effectiveness.

Further, it is unclear if the current hunting system is efficient enough to reduce damages to livestock by arctic foxes. At the moment, the hunting system in Iceland is based on economic incentives for each hunted individual. Hunters receive money for every arctic fox they kill by presenting proof of the kill (arctic fox tail) to the municipalities. This bounty system does not include any ecological factors such as arctic fox abundance and amount of arctic fox predation on livestock. Hence, this approach can generate uncertainty on the effectiveness of the hunting by not knowing if the hunting efforts reduce damages to livestock. Moreover, it increases the risk of overhunting since a high number of hunted arctic foxes implies more economic output for each hunter. To reduce the dependency of hunters to the amount of hunted arctic foxes, it would be beneficial to develop a hunting regime that is not based on a bounty system, but provides certain financial security to hunters. Such financial security can be attained by actively involving hunters in research and management actions. This would be beneficial not only for the hunters, but also for the management of the species because it would include important hunter knowledge and experience. For instance, hunter participation would be very valuable in assessments of arctic fox population size using mark and recapture techniques or in studies on livestock damages and arctic fox migration via tagging and satellite tracking of arctic foxes. This inclusive approach would strengthen and validate management actions because it would help bring together stakeholders such as hunters, farmers, scientists and politicians. Furthermore, involving key stakeholders in the decision-making process regarding arctic fox management in Iceland would also help guarantee that management actions are supported by the public.

The current legislation of law no. 64/1994 requires the Minister for the Environment and Natural Resources to consult with the Icelandic Institute of Natural History in order to approve hunting proposals with scientific recommendations. This requirement, however, has never been implemented and shows that hunting efforts at the moment are solely based on financial matters. Thus improving stakeholder participation would help increase collaboration between the Icelandic Institute of Natural History and the Minister for the Environment and Natural Resources. The inclusion of scientific and political aspects are central to developing a sustainable and effective arctic fox management plan in Iceland.

3.4.2 Metapopulation/Migration studies

Another important factor to ensure the health of the arctic fox population is to understand the migration of the species between regions in Iceland. Moreover, it is important to determine if different subpopulations exist and whether there is genetic exchange among them. This information would not only give an insight into the intraspecific relationship between arctic foxes, but also facilitate managing the species (Olivier et al., 2009) during events of sudden population changes (e.g., spreading of diseases, decrease in numbers). Knowing which populations are connected through migration can help with rapid response actions and focus management strategies to specific areas. For example, Norén et al. (2009) showed that the arctic fox population in the north-western part of Iceland can be considered genetically isolated for over 100-200 generations. This finding is further validated by the dissection of thousands of arctic fox carcasses for 32 years by researchers in Iceland, which revealed that ear mite (*Otodectes cynotis*) infections in arctic foxes only occur in the north-western part of Iceland (Unnsteinsdóttir, 2013). Fostering more research on the migration of arctic foxes between regions in Iceland will also contribute to allocate hunting efforts where they are needed most.

3.4.3 Emerald Network

The arctic fox is protected in 26 sanctuaries because of a total ban of hunting in these areas. However, none of these areas were originally established to protect arctic foxes specifically; hence it is unclear if they are sufficient to ensure the viability of this species in Iceland. Nonetheless, the ban on hunting the arctic fox in these areas represents an important step towards implementing the provisions of the Bern Convention and the CBD to establish an *in situ* conservation network (Council of Europe, 1979; Secretariat of the Convention on Biological Diversity, 2005). Iceland, however, has yet to develop a network of protected areas within the country to join the Emerald Network of the Bern Convention. Both the size and connectivity of the 26 protected areas need to be evaluated to see if they can be included into the List of Candidate Emerald Sites. Only recently, the Standing Committee to the Bern Convention officially adopted 37 Emerald sites in Switzerland as the first ever to join the Emerald Network (Council of Europe, 2014a). Several other countries have already proposed Emerald sites to be biogeographically assessed in order to join the network. For example Norway has proposed 633 sites that span a total area of 4,296,073.74 ha (Council of Europe, 2014b). Potential sites in Svalbard have not been included because of its several reservations against the provisions of the Bern Convention (Directorate for Nature Management, 2007; St. prp. nr. 12, 1985-86). Presently, Iceland has not proposed any sites to the Emerald Network, but aims to join the tentative list of the network in the near future. This will be another major step for Iceland because the proposed network of protected areas is internationally evaluated and it gives the

opportunity to improve the country's existing network of protected areas. As for the arctic fox in Iceland, it is important to protect both main habitat types where the species occurs (coastal and inland habitats) to ensure its genetic diversity in the long-term. Consequently, to fulfil the obligations of the Bern Convention, it is necessary to propose a network that is interconnected via natural corridors and contains large enough areas of coastal and inland habitats to ensure a thriving arctic fox population and maintain ecosystems.

3.4.4 Minimum viable population (MVP)

Ultimately, it is beneficial to examine the minimum population size of arctic foxes that is needed to ensure the long-term survival of the species in Iceland. This analysis will allow the adaptation of management actions to minimize the risk of extinction in the long-term. Especially, in the light of future potential effects caused by climate change (e.g., changes in habitat and food resources), knowledge on the minimum population size needed for the long-term survival of arctic foxes will also contribute to the species' resilience in Iceland. Currently, such a study on the arctic fox population is underway at the Icelandic Institute of Natural History. The outcome of this study will depend on the data available to determine a minimum viable population. However, it is a common approach in conservation biology to develop such a study sometimes decades before more detailed information is available that can complement the already existing information (Thomas, 1990). Such a study can help to prepare potential future management actions that take into account genetic viability and diversity, and the uncertainty of extreme conditions (e.g., extreme weather events, volcanic eruptions, etc.). To be able to adjust the management to potential changes over time requires a consistent long-term monitoring that aims to ensure that the size of the arctic fox population is large, and diverse enough to withstand these changes. The precision of a future minimum viable population analysis would benefit from the implementation of the recommendations highlighted here. Nonetheless, it is an important achievement in Iceland to provide decision-makers with up-to-date scientific information that takes into account uncertainty, risk and long-term variability. This would not only improve the resilience of Iceland's arctic fox population, but also contribute to the current hunting regime, which could then be adjusted to the protection of Iceland's ecosystems.

3.5 Conclusion

The adjustment of the international provision to Iceland's national characteristics is necessary for developing a realistic management framework for the arctic fox in Iceland. It is clear that the current implementation process ushered major changes in Iceland's legislative body concerning the arctic fox and other species. This development led to a comprehensive legislative body, which is accompanied by a continuous reviewing process with the aim to account for international obligations and the change of national perceptions towards nature. To accomplish the ambitious goal of managing the arctic fox in a sustainable way, it is important to develop management actions that support both the long tradition of hunting the species in the country and the long-term viability of the entire population.

The current state of the legislation promotes the protection of the species as a protection against a decrease of its well-being. Since the well-being of a species is defined as the viability of the whole population, it is allowed to hunt arctic foxes during a defined period

in the year in all non-protected areas. But the legislation also states that the evaluation of the well-being of a species should be based on research, which involves a consistent monitoring scheme. Up until now, the analysis of the health of the population is mainly based on examining culled arctic foxes, which are voluntarily sent to the Icelandic Institute of Natural History by supportive and cooperative hunters throughout the country. One step to further support the existing research is to develop an environmental monitoring program that is based on indicators. The example of Svalbard shows that the arctic fox is regarded as a priority and indicator species for the entire archipelago. Research, however, is limited in Svalbard because of the prevailing harsh environmental conditions in the Arctic (e.g., polar night, cold temperatures, etc.). Nonetheless, the approach of highlighting the species as one of several indicators (e.g., Svalbard reindeer, Svalbard rock ptarmigan, vegetation, etc.), that are part of the Environmental Monitoring of Svalbard and Jan Mayen (MOSJ), allows to evaluate the state of Svalbard's terrestrial environment as a whole (Ims et al., 2014). The MOSJ uses one stable variable (annual den occupancy) from two monitoring areas (see Chapter 2). Other variables (e.g., litter size, impact on cliff-nesting seabirds,) are also analysed but not included into the MOSJ. By combining different indicators, Svalbard's environmental studies are building the foundation for a holistic perspective on the actual health of the ecosystems on the archipelago. Such a research approach would be advantageous for Iceland's environmental protection because focusing on key indicators takes into account the limited financial resources and allows to combine study outcomes of different species and/or ecosystems in Iceland. Hence, the arctic fox could be one of these important indicators and represent a valuable contribution to the protection of the environment in the country.

The management of arctic foxes in Iceland would also benefit by considering the species as a national priority because of its special status as the only native terrestrial mammal in Iceland. The prioritization of the species in Svalbard showed that the importance of the species for Svalbard's ecosystems has been highlighted. This led to comprehensive research regarding the arctic fox on the archipelago. Such a prioritization of the species in Iceland, together with the inclusion of the species' special cultural heritage regarding hunting can be a great opportunity to foster a change in Iceland's perception towards its arctic fox population. Although, today's legislations in Iceland are mainly built around the hunting of the species in order to prevent damage to livestock, inclusive management procedures can be developed to meet the goals to reduce damages from arctic foxes and the sustainable use of the country's natural resources.

This study represents an important step towards the protection of Iceland's natural and cultural heritage by focusing on only one species. Further, it can be seen as a good example to develop management strategies for other Arctic islands with arctic fox populations to promote the overall long-term survival of the species on a global scale. Iceland serves as an example of a sea ice free arctic fox population and can, hence, contribute to potential management strategies on other Arctic islands that will become free of sea ice in the future due to climate change. With its thriving arctic fox population and a sophisticated management plan, Iceland could be a guiding light for other countries that face equal transitions. It is important to acknowledge that such a change has to evolve over time, and Iceland's enormous transformation and achievements over the last 20 years are a very positive development. Iceland is therefore contributing to finding solutions to the ecological challenges humanity faces today. A change in perception towards arctic foxes in

Iceland will not only benefit the species, but also heighten society's awareness of the importance of protecting nature for human health and welfare.

3.6 References

- Alþingi, 2013. Lög um vernd, friðun og veiðar á villtum fuglum og villtum spendýrum nr. 64/1994 [e. Protection and Hunting of Wild Species Act no. 64/1994]. URL: <http://www.althingi.is/lagas/143b/1994064.html> (accessed 7.8.15).
- Alþingi, 2012. Lög um náttúruvernd nr. 44/1999 [e. Nature Conservation Act no. 44/1999]. URL: <http://www.althingi.is/lagas/143b/1999044.html> (accessed 6.6.15).
- Council of Europe, 2014a. Emerald Network Reference Portal. URL: http://www.coe.int/t/dg4/cultureheritage/nature/EcoNetworks/portal_en.asp (accessed 8.25.15).
- Council of Europe, 2014b. List of candidate Emerald sites (December 2014). URL: <https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=2688229&SecMode=1&DocId=2232868&Usage=2> (accessed 8.25.15).
- Council of Europe, 1979. Bern Convention on the Conservation of European Wildlife and Natural Habitats.
- De Klemm, C., Shine, C., 1993. Biological diversity conservation and the law: Legal mechanisms for conserving species and ecosystems. IUCN.
- Directorate for Nature Management, 2007. Emerald Network in Norway - Final Report from the Pilot Project.
- Fuglei, E., Prestrud, P., Vongraven, D., 1998. Status of the Arctic fox *Alopex lagopus* in Svalbard [no. Status For Fjellrev *Alopex lagopus* På Svalbard].
- Helgason, H., Ancin, F.J., Unnsteinsdóttir, E.R., 2013. Estimation of lamb (*Ovis aries*) mortality during summer in Iceland, a step towards estimating costs and benefits of arctic fox (*Vulpes lagopus*) culling. Presentation presented at the 4th International Conference in Arctic Fox Biology, Hotel Nupur, IC.
- Hersteinsson, P., 1980. Refir [e. Arctic Foxes], in: Einarsson, Á. (Ed.), *Villt spendýr. Rit Landverndar*.
- Hersteinsson, P., Macdonald, D.W., 1996. Diet of arctic foxes (*Alopex lagopus*) in Iceland. *J. Zool.* 240, 457–474. doi:10.1111/j.1469-7998.1996.tb05298.x
- Ims, R.A., Alsos, I.G., Fuglei, E., Pedersen, A.Ø., Yoccoz, N.G., 2014. An assessment of MOSJ - The state of the terrestrial environment in Svalbard. Tromsø: Norsk Polarinstitut. Rapportserie, 144.
- Ministry for the Environment and Natural Resources, 2015. International co-operation [e. Alþjóðlegt samstarf]. URL: <http://www.umhverfisraduneyti.is/althjodlegt-samstarf/> (accessed 7.7.15).

- Ministry of Climate and Environment, 2012. Lov om miljøvern på Svalbard [e. Svalbard Environmental Protection Act]. URL: <https://lovdata.no/dokument/NL/lov/2001-06-15-79> (accessed 8.20.15).
- Ministry of Climate and Environment, 1998. Norway's National Report on the Implementation of the Convention on Biological Diversity.
- Norén, K., Angerbjörn, A., Hersteinsson, P., 2009. Population structure in an isolated Arctic fox, *Vulpes lagopus*, population: the impact of geographical barriers. *Biol. J. Linn. Soc.* 97, 18–26. doi:10.1111/j.1095-8312.2009.01172.x
- Norwegian Biodiversity Information Centre, 2010. Norsk Rødliste for arter 2010 [e. The 2010 Norwegian Red List for Species]. URL: <http://www.artsdatabanken.no/Databank?query=fjellrev> (accessed 8.20.15).
- Norwegian Polar Institute, 2015. Bag of Arctic foxes (*Vulpes lagopus*). URL: <http://mosj.npolar.no/en/influence/hunting/indicators/arctic-fox-hunting.html> (accessed 8.20.15).
- Olivier, P.I., Van Aarde, R.J., Ferreira, S.A.M.M., 2009. Support for a metapopulation structure among mammals. *Mamm. Rev.* 39, 178–192. doi:10.1111/j.1365-2907.2009.00143.x
- Reglugerðasafn, 2014. Reglugerð um refa- og minkaveiðar nr. 437/1995 [e. Regulation on the hunting of Arctic foxes and minks no. 437/1995]. URL: <http://www.reglugerd.is/reglugerdir/eftir-raduneytum/umhverfisraduneyti/nr/4354> (accessed 8.20.15).
- Schmalensee, M. von, Skarphéðinsson, K.H., Vésteinsdóttir, H., Gunnarsson, T.G., Hersteinsson, P., Arnþórsdóttir, A.L., Arnardóttir, H., Hauksson, S.B., 2013. Vernd, velferð og veiðar villtra fugla og spendýra [e. Protection, welfare and hunting of wild bird and mammals]. Lagaleg og stjórnsýsluleg staða og tillögur um úrbætur. Skýrsla unnin fyrir umhverfis- og auðlindaráðherra.
- Secretariat of the Convention on Biological Diversity, 2005. Handbook of the Convention on Biological Diversity Including its Cartagena Protocol on Biosafety, 3rd edition. Montreal, Canada.
- St. meld. nr. 22, 1994-95. Oslo: Miljøverndepartementet.
- St. meld. nr. 9, 1999-2000. Oslo: Justis- og Politidepartement.
- St. prp. nr. 12, 1985-86. Oslo: Utenriksdepartementet.
- Thomas, C.D., 1990. What Do Real Population Dynamics Tell Us About Minimum Viable Population Sizes? *Conserv. Biol.* 4, 324–327. doi:10.1111/j.1523-1739.1990.tb00295.x
- Unnsteinsdóttir, E.R., 2013. The fox tax - a brief overview of Conservation and Management of Arctic foxes in Iceland. Presentation presented at the 4th International Conference in Arctic Fox Biology, Hotel Nupur, IC.

Victor, D.G., 1998. The implementation and effectiveness of international environmental commitments: Theory and practice. MIT press.