WILDLIFE MANAGEMENT IN THE ANTHROPOCENE

Perspectives from Norway

Scott Michael Brainerd and **Torstein Storaas**

Scandinavian University Press

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About the cover art: In the Anthropocene era, human activities can pose significant challenges to wildlife conservation. In Norway, wind farms designed to combat climate change may affect wildlife and habitats, symbolized by this photo of a black grouse with wind turbines encroaching on its natural environment. Photo: Sondre Vaagen.

Abstract Wildlife management is a process of setting goals and actions to learn from and influence interactions between wildlife, habitat and humans in order to achieve objectives in consultation with interest groups based on the best available knowledge and practices. It includes knowledge of species biology, ecology and habitat relationships, as well as knowledge of values and valuation, interest groups and legislation and scientific methods. Non-native species, new diseases, land development which leads to landscape fragmentation and loss of habitat, and conflicts between wild species and humans represent major challenges for wildlife managers. Hunting management is a balancing act between healthy game populations and human needs.

We live in the Anthropocene, the age of humans. Humans are a very special animal species that can believe in common ideas and values and cooperate toward common goals. We attempt to tame and reshape nature that has provided us with sustenance. Our actions have benefited many people but have also led to habitat loss and extinction.

Humans and livestock comprise 95–99% of the biomass of terrestrial mammals. People who can view or hunt wild animals are privileged. How we affect biological diversity, wildlife and nature is up to us. Wildlife only survives if we want it to. Complete protection is sometimes necessary, but we can also sustainably use wildlife. Hunting creates advocates for wild nature when we see ourselves as part of nature. Wildlife management is an overall important activity that must be continuously improved as new knowledge and ways of thinking emerge.

Keywords wildlife | sustainability | values | regulations | management | anthropocene | habitat

Contents

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Preface

We are living now in the Anthropocene epoch (Crutzen, 2002) – the age of humans. During the Ice Age there were no humans living in the Nordic region; however, today Norway, Sweden and Finland have population densities of 14, 24 and 18 people per km^2, respectively (World Bank Group, 2016). Our decisions and actions determine not only our fates as human beings, but also all other living organisms on our planet. The extinction rate for species is now 1,000 times higher than it was before the Anthropocene (Pimm et al., 2014) due to human activity. We emit greenhouse gases, pollutants and waste, fragment landscapes and destroy wildlife habitat, leaving an indelible imprint on the environment. The greatest challenge we face is global warming, with the most significant temperature increases occurring in the polar regions. In this context, wildlife management is being conducted toward a new horizon dominated by our overwhelming influence on the planet, as the cover image symbolizes.

In Fennoscandia, there has also been a continuous migration of people from rural areas to regional centers and cities (Sørlie, 2010), leading to emigration, particularly of younger people, from rural areas (Aasbrenn, 1989). Modern technology has facilitated the efficient utilization of natural resources that requires fewer people. In Norway, "wilderness" (defined as areas less than 5 km away from major technical infrastructure) continues to decrease (Miljødirektoratet, 2016b). Ironically, although these formerly remote areas are more accessible by road, they are used less than in historic times because fewer people inhabit and use renewable resources such as game, firewood and berries in these more remote areas. Nowadays human activity is clustered in resort villages, towns and cities and on roads and trails. In some larger rural municipalities in Fennoscandia, human densities are now less than one person per square kilometer.

Our perceptions of wildlife and nature have shifted. Where once we only considered wild animals as either useful or harmful from a utilitarian perspective, modern management has become part of broader biodiversity conservation governed by the Norwegian Nature Diversity Act[1]. Rural depopulation, changes in attitudes and new legislation and international agreements have paved the way for recovery and increase in many large ungulate and predator populations in Fennoscandia and Europe. At the same time, several small game species are struggling—the ptarmigan species (*Lagopus* sp.) were and the mountain hare (*Lepus timidus*) is on the Norwegian Red List[2].

1 https://www.regjeringen.no/en/dokumenter/nature-diversity-act/id570549/

2 https://artsdatabanken.no/Pages/135380/Norwegian_Red_List_for_Species

As authors, we are concerned with how we can manage wildlife resources in this new psychological and physical landscape. Wildlife management is interdisciplinary. We need historical knowledge of the historical context and the modern situation, and an understanding of the landscape, human perceptions and legal frameworks and how these interplay in our management of wildlife. Biological knowledge about populations, methods of monitoring and management measures is vital. Equally important is the ability to make proper decisions based on limited information.

Wildlife management is dynamic, with ever-changing rules and challenges. Legal, ecological and scientific conditions can be vastly different tomorrow than they are today. Chronic Wasting Disease (CWD), first detected in wild reindeer in Nordfjella in 2016 and on the Hardanger Plateau in 2020, was unforeseen and has had major consequences for deer management in Norway and Sweden (Tranulis et al., 2021)[3].

While writing this book, we found that new knowledge was constantly emerging. We attempt here to compile a multidisciplinary knowledge base on modern wildlife management, emphasizing the Norwegian context. Much has changed since the last book on Norwegian wildlife management was published 29 years ago (Storaas & Punsvik, 1996). Thus, it is time for an update. This book is a translation of Storaas and Brainerd (2024) with some supplementation.

We thank the Gotaas Fund, the Wildlife Fund and the University of Inland Norway for supporting this publication. Editorial feedback from Ida Almestad, Camilla Mevik, Hedda Barratt-Due and two anonymous reviewers improved the manuscript. Valuable comments were provided by Knut Nicolaysen, Marius Knudsen and Torgal Sætre. Jorrit van Grieken edited the reference section. Gertrud Brekke made this book possible by generously allowing her husband, Torstein Storaas, to devote endless retirement hours to writing the Norwegian version. Scott Brainerd has translated this text into English with some supplemental information to provide readers with a better understanding for those unfamiliar with the Norwegian situation.

Moderately wise
every man should be
He should not be overly wise.
Life is easiest to live
for the one
who knows something.
— Odin in Hávamál

3 https://link.springer.com/article/10.1186/s13028-021-00606-x

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1. Wildlife management—biology, but mostly about people

The field of wildlife management has evolved significantly over time. In the 1970s, conservationists and many professional ecologists perceived nature as being in balance (see Walter, 2008). Today, we understand that nature is constantly changing on its own and that major changes are driven by human activities (Ellis, 2015). Our era is called the Anthropocene, the age of humans, due to our massive impact on the planet (Crutzen, 2002). In 2022, the global population exceeded 8 billion people. It is striking to consider that the combined weight of our dogs and cats matches the weight of all wild land-dwelling mammals (Greenspoon et al., 2023). Humans are altering natural systems at a pace that causes species to go extinct much faster than before (Kolbert, 2015). Recorded wildlife and fish populations globally have declined by 69% over nearly 50 years (WWF, 2022). This decline is influenced by the calculation method, which heavily weighs a few populations experiencing much larger declines than the rest (Leung et al., 2020). There is significant variation in how populations are faring, with the greatest declines in Latin America and the Caribbean, Africa, South Asia and the Pacific, while conditions are better in northern regions (McRae et al., 2022; WWF, 2022). Regardless, nature and wildlife are in crisis and require wise management—it is a major challenge to mobilize people to take action before it is too late.

During the 1970s and 1980s, we and our fellow students learned a great deal of evolutionary ecology at university. Many of us went on to work in management or research roles. Occasionally, when we presented research findings and offered management advice, we were met with distrust and criticism. The biology was consistent with our training, but we were unaware that the values held by academics at the university often differed from those of the general public. Often, values and economics are as important as ecology when individuals or authorities make decisions. Aldo Leopold (1943) stated that managing wildlife is easy, but getting people to manage it correctly is difficult. By "correctly," he meant in a way that is best for wildlife—and hunters. Today, "correct" means what is best for ecosystems, biodiversity, the general public—and, ultimately, hunters. Wildlife management has had to evolve to meet new challenges.

Challenges related to the loss of nature and wildlife have also been addressed through other disciplines such as conservation biology, landscape ecology and restoration ecology (see Mace, 2014; Kaltenborn & Linnell, 2022). We perceive wildlife management to have, unlike other fields, a long tradition with a primary focus on the use of wildlife resources. In our time, the use of wildlife must be placed within a broader context where human will, attitudes, politics and legislation play a central role, and the conservation of native species and control of invasive species is at least as important as harvesting. We have felt the absence of this and thus attempted to create a comprehensive overview of what the multidisciplinary field of wildlife management has become in the Anthropocene. We have not seen similar comprehensive works on wildlife management from a Norwegian perspective and offer here some insights into what the various chapters contain.

STRUCTURE AND ORGANIZATION OF THE BOOK

Chapter 1 introduces the field of wildlife management. We begin by emphasizing that the authors are present in the text. Thousands of relevant articles are available, and we have cited many but not all. Readers should critically evaluate the content and consult other sources. We discuss the evolution and distinctive characteristics of humans, reviewing human migration from Africa, the extinction of megaherbivores and the development and spread of agriculture. Although the importance of wildlife has diminished, it still holds significance for many. This chapter defines wildlife and wildlife management, providing a foundation for understanding the subsequent chapters.

Chapter 2 examines Norway's transformation from a barren ice-covered region to a land of vegetation, wildlife and people following the Ice Age. This chapter highlights Norway's unique features, driving environmental forces, human impacts on the environment and changes in large and small game populations over time, up until and including the Anthropocene. It emphasizes the complexity of nature, gradual changes and the potential for unexpected events.

Chapter 3 focuses on human behavior and perceptions. Wildlife managers have often failed due to a lack of understanding of human perspectives, leading to the growth of a discipline devoted to the relationship between people and wildlife. This chapter explores how individuals perceive and value nature along various scales. Successful wildlife management requires robust knowledge of attitudes, beliefs, values and norms. We discuss species categorization and differing viewpoints, stressing that understanding and respecting diverse opinions is essential to mitigating conflict in nature conservation.

Chapter 4 delves into legislation and conventions relevant to wildlife conservation and management, emphasizing legalities concerning sustainable use and protection of wildlife resources. The chapter covers international conventions, as well as the evolution of Norwegian law and key regulations. Although legal matters may seem tedious, they provide the essential framework for the management of wildlife. Tales of how laws have developed, including how common hunting rights in Norway were appropriated by landowners and the wealthy, provide intriguing insights. Several recent legal cases illustrate how courts currently interpret wildlife issues in Norway.

Chapter 5 explores variations in wildlife laws and management systems shaped by culture and history worldwide. In some nations, all wildlife is protected, while in others, hunting rights belong either to landowners or to the public. Access rights to land may be private or public. These systems are not naturally given but are products of history and power dynamics. Learning from different approaches can offer valuable inspiration and understanding of the various models of wildlife management around the world. Our overview is not comprehensive, but we use examples from a few countries to illustrate a variety of approaches and models of wildlife management worldwide.

Chapter 6 focuses on biology and interactions between plant communities, predators, prey and humans. It delves into various factors that wildlife managers need to understand and influence. Species have different life strategies; some are capable of rapid population growth, while others live longer with slower potential growth. Populations can be limited from above by predation or from below by resource availability. Documenting what determines population sizes can sometimes be challenging, while at other times it is easier.

Chapter 7 addresses wildlife monitoring. The precision required for population estimates varies greatly between species. The chapter presents various monitoring methods that managers and stakeholders can choose from to find the most suitable for different species. Monitoring is crucial for detecting changes in nature, and national organizations and programs have been established for this purpose.

Chapter 8 is brief, but the knowledge of management under great uncertainty deserves its own chapter. Through various forms of experimental and adaptive management, managers can gain knowledge through systematic planning, implementation and evaluation of management measures. This systematic approach can transform wildlife management from art to science.

Chapter 9 finally turns to the concrete management of animal species, focusing on how to protect vulnerable and threatened wildlife species that are struggling. Understanding the causes of declines and what measures to implement can be difficult. The chapter discusses how three animal species are being protected through dedicated programs. The Arctic fox will depend on ongoing measures if global warming is the reason for its decline. Measures to improve adult survival can help the Eurasian eagle owl, which struggles to find enough prey for young production. The lesser white-fronted goose faces predation from foxes in breeding areas and harvesting during migration and in wintering areas, and Norwegians and Swedes have devised different survival strategies.

Chapter 10 explores threats from invasive species. Several non-native species have reached or are approaching Norway with human assistance. The chapter discusses the management of three such species. The American mink is a well-established predator of seabird eggs and chicks and is challenging to eradicate. Wild boars have been here before; they are considered native in Sweden and are spreading across the border. The political goal is to keep their population low in a small area. Norway supports the effective eradication of raccoon dogs, including using Judas animals in Sweden. The concept of invasive species is discussed.

Chapter 11 covers harvestable wildlife species, traditionally one of the most important fields for wildlife managers. Harvesting is considered a threat to many species. The chapter begins by breaking down the concept of harvesting into subcategories and presents different ways to regulate it.

Chapter 12 addresses one of the most critical tasks for wildlife managers: cervid management. The goal is for hunting rights holders to manage deer populations using management plans over large areas, with plans for wild reindeer approved by regional reindeer boards and for moose, red deer and roe deer by municipalities. The chapter discusses the management of different species and addresses wildlife collisions, which have been an unresolved issue since deer populations began increasing in the 1970s.

Chapter 13 discusses the management of grouse species. These populations are typically kept low due to predation, with survival and production influenced by various factors that do not align with each other. The chapter explores how managers can impact these populations.

Chapter 14 examines the management of other small game species that provide good hunting opportunities for relatively few hunters. It assesses the level of monitoring and knowledge about different species and discusses the potential impact of hunting on their populations.

Chapter 15 delves into the complex field of predator management. It discusses how different people perceive predators, provides an overview of predator management with precise goals set by the Norwegian Parliament and addresses the management of different predator groups and species. Opinions, particularly regarding wolf management, are often highly varied and emotionally charged.

Chapter 16 explores the conditions for wildlife as an industry in Norway. As seen in Chapter 5, wildlife industries are significant in several countries, and the Ministry of Agriculture and Food aims to further develop this industry in Norway. The chapter reviews potential measures to promote populations of moose, red deer and grouse. Developing a sustainable industry largely requires cooperation among various landowners, which can be challenging.

Chapter 17 contains brief summaries of each chapter and some subjective final thoughts on the challenges and the importance of effective wildlife management in the future. It emphasizes that people's choices and policies significantly determine the future of wildlife.

Each chapter can be read independently, depending on the reader's need for knowledge. Beginning with Chapter 1, the initial reading serves as a warning that the selection and perspective of the material are heavily influenced by the authors' values and attitudes.

BACKGROUNDS SHAPING THE AUTHORS

How we perceive wildlife is, and always has been, a matter of values. People's values depend on time and place, upbringing, education and external influences. Author Torstein Storaas grew up in Hardanger, too far down the fjord to have wild reindeer rights on the Hardanger Plateau and too far inland to have any significant deer population. Wildlife and hunting were peripheral for most people. Small-game hunting permits were inexpensive, but few landowners allowed hunting with dogs out of fear they would chase sheep. Small-game hunting was an occasional pastime for the few. Storaas began studying ecology to understand how he could always maintain a good population of black grouse (*Lyrurus tetrix*) on his hunting grounds. His background is shaped by the forest grouse research environment at Varaldskogen under Professor Per Wegge, his research at the Evenstad campus of the Inland University of Norway, as well as hunter and landowner communities in Østerdalen, Norway, near the campus where he worked for over 35 years as a professor of wildlife management.

Author Scott Brainerd grew up in an outdoor-oriented family and spent much of his free time in the mountains and forests of his native state of Washington in the Northwestern United States. During stays with his uncle on a ranch in British Columbia, he became deeply interested in hunting and the ecology of moose (*Alces alces*), bears (*Ursus* sp.) and other wildlife. As a teenager, he worked at a state-managed game farm near his home, raising several thousand pheasants (*Phasianus colchicus*) annually and conducting control of their mammalian and avian predators. This led him to question whether he enjoyed producing live targets for thrill-seeking hunters who knew little about wildlife. At age 18, he moved to Alaska, seeking wilderness experiences, and earned a bachelor's degree in wildlife management and worked primarily for the Alaska Department of Fish and Game between school years and after he graduated. Later, he earned a master's degree at the University of Montana, studying bobcats (*Lynx rufus)* and Canadian lynxes (*Lynx canadensis*) in the Rocky Mountains, and later completed a Ph.D. on Scandinavian pine martens (*Martes martes*) at the Agricultural University of Norway. He worked for 15 years as a wildlife management consultant for the Norwegian Association of Hunters and Anglers and seven years as a wildlife researcher with the Norwegian Institute for Nature Research. He returned to Alaska for 11 years as a research supervisor with the Alaska Department of Fish and Game before returning to Norway to teach wildlife management at Evenstad in 2019.

We authors have spent our professional lives investigating what determines wildlife abundance, the effects of hunting, public attitudes and how populations can be manipulated. Our personal enjoyment of wildlife viewing, hunting and outdoor recreation has shaped our perspectives as authors. Readers are encouraged to be mindful of how our personal values and perceptions may color this text, where we tend to focus on game species. The emphasis here is not solely on wildlife biology and concrete facts but also on human desires and interests, including those of us, the authors.

RELIABLE KNOWLEDGE AND THE "WOOZLE EFFECT"

Readers must remain vigilant not only about the authors' values but also about the reliability of the knowledge presented. Romesburg (1981) pointed out how repeated research hypotheses can evolve into perceived laws simply through repetition. This phenomenon has been described as the "Woozle Effect", inspired by a story by A. A. Milne (1926). In the tale, Winnie-the-Pooh and Piglet follow tracks in the snow, convinced they are tracking a creature called a woozle. With each lap around a tree, more tracks appear, reinforcing their belief, until Christopher Robin reveals they have been following their own footprints.

Humans excel at finding patterns and crafting plausible narratives (Taleb, 2010). A compelling story is easy to believe. In 1976, the Swedish Society for Nature Conservation developed plans for wolf (*Canis lupus*) reintroduction, and wolves later appeared where the group suggested. Historical uncertainty about captive wolves in zoos, anecdotal reports of suspicious vehicles and footprints on remote roads fueled suspicions of clandestine reintroductions (Toverud, 2001). Opponents of wolf recovery find it tempting to accept this hypothesis as fact. Yet alternative explanations also exist, and genetic analyses clearly link Scandinavian wolves to Finnish populations, not captive wolves from elsewhere (Liberg et al., 2012; Stenøien et al., 2021).

Belief does not equate to truth. Wildlife biology and management have their share of woozle tracks. The authors themselves fell into one trap: egg predation in forest grouse nests was attributed to corvids based on photos of eggs with what appeared to be pecked holes (Wegge et al., 1979). Later research revealed that similar holes could be caused by captive martens, and video evidence showed female grouse defending nests against unsuccessful ravens (Jahren, 2017). Despite a better understanding, some still blame corvids for nest predation. Distinguishing hypotheses from verified facts remains critical in understanding underlying drivers that can influence our management strategies.

WILDLIFE AND PEOPLE UP TO THE PRESENT (ANTHROPOCENE)

During the era of the dinosaurs, mammals were small and inconspicuous. About 65 million years ago, a meteor struck the Yucatán Peninsula in Mexico, causing dust and smoke to block sunlight. The resulting frigid temperatures led to the extinction of the mostly cold-blooded dinosaurs (Hildebrand, 1993). Only then could mammals emerge and evolve into larger, more dominant life forms.

Humans are among these mammals. Our ancestors diverged significantly from those of chimpanzees more than 6.3 million years ago, although occasional interbreeding occurred before distinct evolutionary branches formed (Patterson et al., 2006). We humans share 98.4% of our genes with our closest relatives, chimpanzees and bonobos (*Pan* sp.; Goodman, 1999), and are classified in the same taxonomic family, Hominidae. Despite these genetic similarities, humans are unique in our capacity for complex thought, language, art and toolmaking. We can grapple with both concrete and abstract problems. Although we are animals, we consider ourselves distinct from other related species.

Harari (2015, pp. 28–41) posits that our greatest distinction lies in our ability to believe in things that do not exist. Humans can devise ethical systems, religions, visions, goals, and seemingly irrational rules. Currency, for example, has value because people collectively believe in it. The moment people stop believing, their value disappears—thus, value is a matter of faith (Harari, 2015).

While a lion remains a lion, a human child may grow up to become Hindu or Christian, vegetarian or carnivore, peaceful or warlike, depending on the social group it joins and his or her own inclinations (Harari, 2015, p. 11). A monkey will never trade a banana for the promise of eternal bananas after death (Harari, 2015, p. 27), because it cannot conceive of an afterlife. Yet young humans may sacrifice themselves for rewards in the hereafter. Belief in shared myths and truths enables cooperation on a vast scale, a uniquely human trait (Harari, 2015, p. 42).

Humans evolved in Africa. One million years ago, early human species began migrating out of Africa, spreading across Eurasia and evolving into new species. Harari (2015) describes how *Homo sapiens* emerged from Africa 70,000 years ago, gradually displacing other human species. While some argue that these early ancestors coexisted peacefully with these other species, available data suggests that we may have driven them to extinction. The genetic material of modern Europeans contains 1–3% Neanderthal DNA (Sankararaman et al., 2014; Vernot & Akey, 2014), indicating occasional interbreeding. This raises the question of whether these six ancient human species were truly distinct or merely variations of one species, since they could produce fertile offspring.

Traditionally, humans were thought to have lived in small groups of hunter-gatherers before the advent of agriculture. Recent discoveries, however, suggest diverse living arrangements, with widespread cultures, shared values and annual gatherings. In regions with abundant populations of fish, game or nuts, permanent settlements existed (Graeber & Wengrow, 2021). Yet resources were often insufficient to support large human populations. In Britain, for example, only 2,500 people occupied the island prior to agriculture (Maroo & Yalden, 2000), and the global population ranged from only 1 to 10 million people (Harari, 2015; U.S. Census Bureau, 2016).

Gautney & Holliday (2015) estimate that prehistoric human densities ranged from one person per 9 to 36 km^2 of habitable land. In marginal regions, densities were likely as low as one person per 2,000 km^2 (Riede, 2009). Early humans in Norway first settled along the coast, where shellfish, fish and marine mammals provided abundant resources (Bjerck, 2016). Inland, food supplies were less reliable. Although precise population numbers are unknown, early Norwegians were few and concentrated near the coast. Specialized groups dependent on single resources, such as reindeer, faced significant risks; entire communities could perish from starvation (Riede, 2009). Historical accounts of famine and starvation also characterize subarctic indigenous populations in North America, where densities could fall below one person per 100 km^2 (Krech, 1978).

Although human populations were small, hunting had significant effects on other species, particularly large, slow-reproducing animals collectively known as megafauna. Definitions of megafauna vary, ranging from animals from 45 kg to over 1,000 kg (Moleon et al., 2020). Following human migration into new areas, 18 species of megafauna disappeared in Eurasia, about 37 in North America, 39 large animal species in Australia, as well as 80% of species in South America (Figure 1.1; Stuart, 2015). There is ongoing debate about whether climate change or human predation drove these extinctions. Different factors likely played varying roles in different regions (Barnosky et al., 2004; Yule et al., 2014).

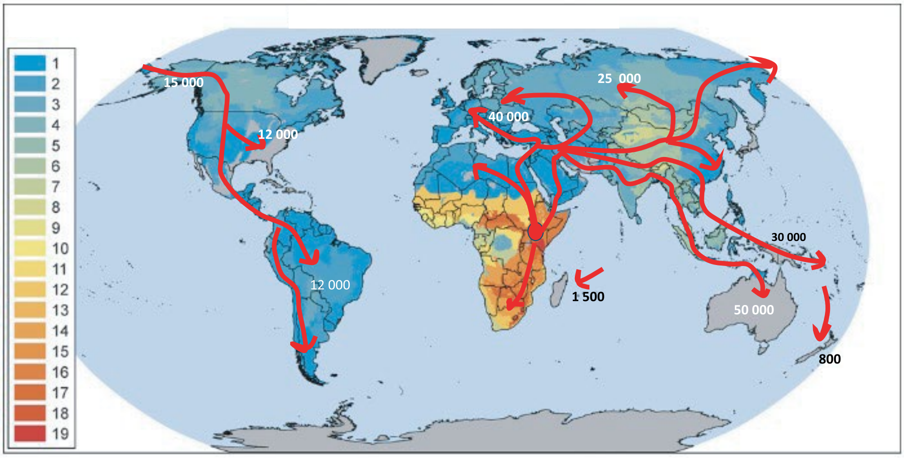

Figure 1.1: The number of species of wild large herbivores (body weight over 100 kg) found around the world (Ripple et al., 2015). Humans and other animal species evolved together in Africa. The numbers in the figure show how long it has been since humans migrated to new areas. Migration routes and times are debated and change with new knowledge. After humans migrated, 18 animal species over 45 kg disappeared in Eurasia, and around 37 species over 45 kg disappeared in North America. In South America, 80% of species and in Australia, 39 species over 50 kg disappeared (Stuart, 2015).

However, evidence strongly suggests that hunting by humans was the primary cause of these extinctions. In North America, archaeologists have traced the southward spread of the Clovis culture, whose campsites contain the bones of now-extinct animals, showing continuous hunting for centuries until the species vanished (Haynes, 2013). In Europe and Asia, species such as the woolly rhinoceros (*Coelodonta antiquitatis*), muskox (*Ovibos moschatus*), aurochs (*Bos primigenius*) and mammoths (*Mammuthus* sp.) likely fell to human hunting (Markova et al., 2013). Birgisson (2014) argues that early Viking prosperity in Iceland partially stemmed from hunting marine mammals, particularly walruses (*Odobenus* *rosmarus*), a view supported by Keighley et al. (2019). Frey et al. (2015) document how walrus ivory from Iceland and Greenland spread across Europe. Sustainable resource use proved difficult; the walrus in Iceland was quickly hunted to extinction. Similarly, when the Maori arrived in New Zealand around 1200 AD, large, flightless birds (Moas: order Dinornithiformes) fulfilled the role of large herbivores. Within 150–200 years, moas survived only in legend, having been hunted to extinction (Perry et al., 2014). There is overwhelming evidence that humans directly caused the disappearance of these megafauna species (Sandom et al., 2014).

The advent of agriculture approximately 10,500 years ago in Mesopotamia led to rapid population growth. Agriculture spread independently in other continents, supporting up to 100 times more people per unit of land than hunting (Diamond, 1997). Harari (2015, pp. 87–109) argues that agriculture brought greater food security at the cost of increased labor and a less diverse diet. Following the Industrial Revolution, urban migration accelerated, and a smaller proportion of the population remained in food production. Over the last century, there has been a mass migration from rural to urban areas. Today, we rely on fossil fuels for energy and industrial-scale, fertilizer-based agriculture, mechanized fishing and aquaculture for food. From 1–10 million humans before agriculture, the global population has risen to over 8 billion in 2022, profoundly shaping the planet. The Anthropocene, marked by significant fossil carbon use since around 1800 (Steffen et al., 2007), will endure indefinitely.

Rosling et al. (2018) highlight substantial global improvements in human living conditions. Yet these advances have come at significant environmental costs. The Earth's standing biomass has been halved due to deforestation (Smil, 2011). Nearly a quarter of global biological production now feeds into human consumption (Smil, 2011). Flights over fertile regions like the U.S. Midwest or the Netherlands reveal human-dominated landscapes. Even within the largest U.S. national parks, wildlife is affected by pollution, climate change, and proximity to human-modified land (Burns et al., 2003; Dixon et al., 2010; Hansen et al., 2014). Norwegian national parks permit grazing by domestic sheep and reindeer, hunting and fishing. In 2022, wildfires ravaged Southern Europe and North America, driven by drought and heat exacerbated by greenhouse gas emissions. Wildlife biomass, once comprising nearly all land-dwelling mammal biomass, now represents just 1–5% after 10,000 years of human influence (Figure 1.2, Smil, 2011; Pausas & Bond, 2020; Greenspoon et al., 2023). Biomass of pets like dogs and cats equals the combined biomass of the world's all wild mammals. From being vital to human survival, wildlife now holds marginal economic value.

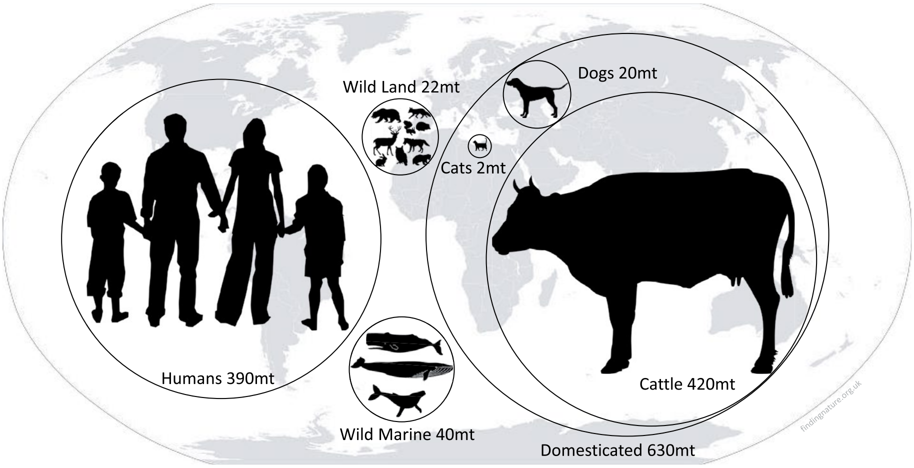

Figure 1.2: Today, the biomass of humans and livestock is estimated to be 95–99% of the biomass of terrestrial vertebrates. "Mt" stands for million tons. Before agriculture, the biomass of humans constituted almost nothing of the total mammal weight (Smil, 2011; Pausas & Bond, 2020; Greenspoon, 2023). The figure is adapted from Miles Richardson based on Greenspoon (2023).

WILDLIFE STILL MATTERS TO MANY

In America, the term "wildlife" commonly relates to free-living terrestrial vertebrates (see Giles, 1978, p. 4; Yarrow, 2009), although there is no consensus and definitions vary. Animals valued for their fur are known as "furbearers", and hunted species are referred to simply as "game", sharing the term with recreational pursuits. This likely reflects historical traditions where hunting was a pastime for kings and nobility. In Hardanger, "dyr" (animals) referred to reindeer, and "fugl" (birds) meant ptarmigan. Even today, reindeer steak is called "dyresteik" (literally "animal meat"). Historically, the Norwegian term "vilt" (wildlife) referred simply to species that were hunted.

The 1981 Norwegian Wildlife Act[1] defines wildlife as wild birds, amphibians, reptiles and terrestrial mammals. Domesticated animals, including semi-domesticated reindeer, are not considered to be wildlife. Whales and seals, however, fall under the jurisdiction of the Fisheries Ministry. This is consistent with old Catholic traditions, where animals like beavers (*Castor fiber*) and seals (Pinnepedia) were classified as fish and could be eaten during Lent (Olaus Magnus, 1555; Danell & Svanberg, 2021; Fridell & Svanberg, 2007). In Sweden, seals and whales are classified as wildlife under the 1987 Hunting Act[2], while reptiles and amphibians are regulated by separate laws.

1 https://www.fao.org/faolex/results/details/en/c/LEX-FAOC013835/
2 https://www.fao.org/faolex/results/details/en/c/LEX-FAOC205789/

In Norway, amphibians and reptiles have never held significant economic value. Hunting rights and game meat do have monetary value, but their relative worth is negligible compared to oil, gas, hydropower, trade, industry, fisheries, aquaculture, forestry and other resources.

Nonetheless, Manfredo (2008) argues that wildlife holds substantial economic importance in many countries, primarily as a driver of tourism. Wildlife viewing motivates travel, making tourism the world's largest industry. In African nations, wildlife-based tourism represents a major source of income. Manfredo also highlights a spectrum of public engagement: relatively few people hunt, more people fish and even more enjoy viewing wild animals, but the vast majority engage with animals via zoos (600 million visitors in 2006) and television programs like *Animal Planet* (237 million viewers across 160 countries in 2005). While few people interact directly with wild animals, interest remains high in controlled or media-based encounters.

Manfredo further explores the genetic basis for human fascination with animals. He contrasts the hunter model, where humans see animals as prey, with the prey perspective, where humans avoid becoming a predator's meal. While he finds no clear evidence that humans must hunt or fish to satisfy innate needs, he concludes that humans are predisposed to be intrigued by animal-like creatures. When exposed to hunting cultures, many people develop a fascination and desire to hunt.

Wildlife remains an integral part of Norwegian cultural heritage. Personal names derived from animals, such as "Bjørn" (bear) and "Ulf" (wolf), have ancient roots. Numerous place names also reference wildlife. In 2016, 69 out of 428 Norwegian municipalities (16%) featured wildlife in their municipal coats of arms, while 12 displayed fish. That some species, such as ptarmigan, appear in multiple coats of arms (Figure 1.3) underscores their cultural importance.

Figure 1.3: When the municipalities of Lierne, Holtålen and Sirdal all have ptarmigan in their coats of arms, it indicates that ptarmigan species are important for the identity of the residents in these communities.

The long-running debate over wolf management has been one of Norway's most contentious political issues in recent decades. This suggests that wildlife holds far greater significance to the public than its direct economic value would imply.

THREATS TO WILDLIFE AND CHANGING PERCEPTIONS

When the authors studied ecology in the 1970s, many ecologists still believed that nature progressed toward a stable climax state. Today, the prevailing understanding is that nature is constantly changing, and the concept of balance was merely an ideal in people's minds (Simberloff, 2014). According to Simberloff, humans must adapt to nature in ways that prevent destructive outcomes for us and other living beings.

Life's foundational conditions are always evolving, and living organisms adapt. Many changes occur independently of human influence, but a significant portion is driven by human activity. The sheer number of people and our demand for food, especially meat and fish, result in profound ecological impacts. We cultivate land, plant forests, trawl the seas, hunt, transform landscapes and develop and fragment habitats with roads and infrastructure. Waste products, including greenhouse gases, alter ecosystems and the atmosphere. Climate change accelerates global warming. Whales now starve with stomachs full of plastic waste. The rapid pace of many changes leaves little time for biological adaptation.

Human sociocultural processes are the most significant force affecting wildlife (Ellis, 2015). These processes—shifts in societal thought patterns, technologies and policies—determine human actions and, consequently, wildlife outcomes. Larger, slow-reproducing animals (K-selected species) are more directly affected than small, fast-reproducing species (r-selected species). Among 74 wild herbivore species averaging over 100 kg in weight, 60% are threatened today (Ripple et al., 2015). Large herbivore diversity is greatest in sub-Saharan Africa, where ecosystems evolved alongside humans. Elsewhere, ecosystems collapsed when humans arrived (Pires et al., 2015; Figure 1.1).

In northern countries, large mammals fare relatively well. European populations of wild hoofed mammals are thriving (Milner et al., 2006; Putman et al., 2011), and white-tailed deer in the United States have the world's highest biomass of any terrestrial wild mammal (Greenspoon et al., 2023). In South Africa, wild ungulate populations rose from 500,000 in 1965 to 17.5 million in 2016, thanks to economic incentives for private landowners (Oberem & Oberem, 2016). Wildlife prospers where laws protect it or where it offers financial rewards. While economic arguments for conservation are persuasive, promoting other values is more challenging. Vynne et al. (2022) demonstrate how reintroducing even a few large mammals could restore more than half of Earth's land ecosystems to conditions resembling those of 1500 AD.

Opinions on large carnivore reintroductions vary. Earlier, people could simply assume Noah saved two of each species in the Ark. Today, public and parliamentary majorities must believe what might be considered a myth that biodiversity matters. For the authors, this is not a myth, but the truth of paramount importance.

Mace (2014) describes conservation as a mission-driven movement that has evolved through four phases:

- **1960–1970**: Focus on species, wilderness and area protection, supported by knowledge of species, habitats and wildlife ecology.
- **1980–1990**: Emphasis on extinction risks, threats to species, habitat loss, pollution and overharvesting, grounded in population ecology and resource management.
- **2000–2005**: Interest in ecosystems, ecosystem services and their economic value, informed by research on ecosystem functions and resource economics.
- **2010 onward**: Concentration on environmental change, resilience, adaptation and socio-ecological systems, with interdisciplinary research.

Kaltenborn and Linnell (2022) similarly review historical conservation paradigms, highlighting overlapping and sometimes conflicting approaches. They conclude that a unified model acceptable to all conservationists is elusive.

DEFINITIONS OF WILDLIFE MANAGEMENT

Wildlife management has traditionally differed from other conservation approaches by emphasizing the consumptive use of wildlife. Here, we aim to understand what wildlife management truly entails. In the 1970s, many claimed that indigenous peoples managed nature sustainably. The famous letter from Chief Seattle of the Suquamish and Duwamish tribes in present-day Washington, USA (Krupat, 2011), was seen as evidence of how well indigenous people managed their wildlife before the arrival of Europeans. However, Kay (1998, 2007) argues that the natives, rather than bears or wolves, were the top predators controlling other animal species. It is important to recognize that there were significant cultural differences among various groups even before the advent of agriculture and European colonization (Graeber & Wengrow, 2021). Some may have managed wildlife sustainably. Historically, in European countries, royalty often had exclusive hunting rights and established hunting reserves and eradicated predators, long before the term “wildlife management” was defined (see Høgh & Perto, 2011).

In our youth, we authors dreamed of being trappers in Canada centuries ago, on the vast tundra and taiga teeming with wildlife. We were disappointed upon seeing an estimate of the number of American beaver (*Castor canadensis*) pelts harvested in North America since the 1600s (Tapper & Reynolds, 1996). Harvest numbers fluctuated over the centuries until they sharply multiplied in the first half of the 20th century. At that time, U.S. authorities implemented measures such as releases, protection and quotas (Organ et al., 1998). Canada transitioned from mere harvesting to agricultural-style wildlife management, giving each trapper exclusive rights to their trap lines. Previously, trappers caught whatever they could to prevent others from taking the beaver (Figure 1.4, Tapper & Reynolds, 1996). The development of the North American beaver population is an excellent example of the importance of harvest regulations.

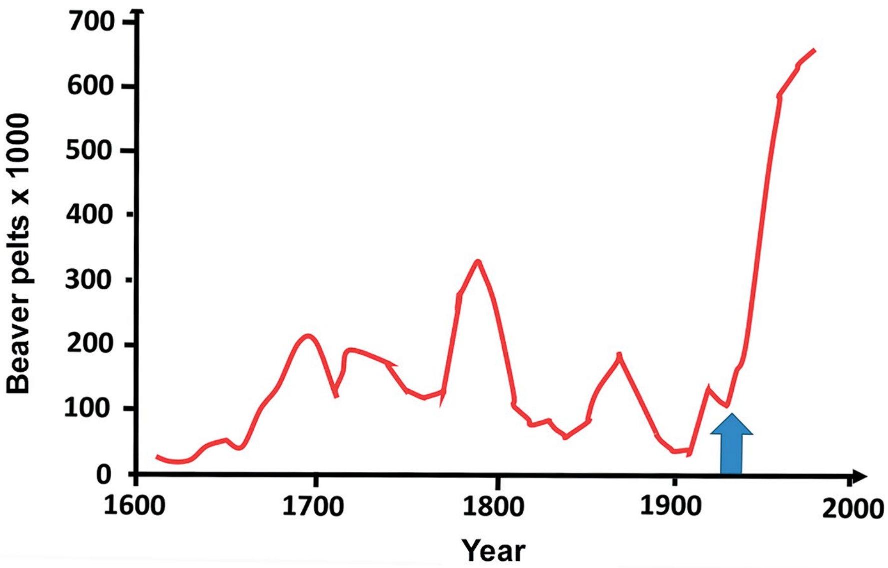

Figure 1.4: Calculated total commercial harvest of beaver skins in North America since 1610. The numbers are averaged for each decade. A significant increase occurred when the system shifted from unregulated harvesting to professional management (marked with an arrow). Adapted from Tapper and Reynolds (1996).

The first to define game management was American Aldo Leopold (1887–1948), considered the father of American wildlife management. In his seminal work, *Game Management*, published in 1933, he defined the concept as “the art of making land produce sustained annual crops of wild game for recreational use”.

Leopold emphasized science as the foundation but described wildlife management as an art, not a science or craft. Artists build on others but copy no one, creating art from something no one else can. We interpret this to mean that a manager must be an artist, perhaps even a magician, to make the right decisions despite uncertain information. Bailey (1982) expands on this, asserting that wildlife management is not a science. A wildlife manager must be knowledgeable in biological and scientific methods, objective, and skilled in communication. They must evaluate and find compromises, especially when decisions are based on limited information. Walker (1998) criticizes the notion of art as allowing for arbitrary opinions and sees wildlife management as a more learning-oriented process where managers gather knowledge about different management approaches and adjust as new information arises.

After Leopold, wildlife management has been defined with varying goals, described as both a science and an art (Giles, 1978; Anderson, 1985; Peek, 1986; Decker et al., 2012). Caughley and Sinclair (1994) state that wildlife management involves managing wildlife, which doesn't provide much clarity. They also outline management goals as 1) increasing populations, 2) decreasing populations, 3) sustainable harvesting, and 4) monitoring populations. Storaas and Punsvik (1996) observed changing goals in wildlife management in Norway. After the 1845 law on predator extermination and bird protection, good wildlife management meant eradicating bears from Norwegian nature. When bears were protected in 1973, good management meant rebuilding the population. By 1996, it was about maintaining the population at a level determined by the Storting (Norwegian Parliament). Building on Caughley and Sinclair (1994), Storaas and Punsvik (1996) proposed a definition without specifying goals:

> Wildlife management is the targeted effort by humans to conserve, harvest, increase, or limit wildlife populations.

This definition highlights that wildlife managers implement targeted measures based on varying political goals.

The Norwegian government (Regjeringen, 2016) does not define wildlife management but states which species it covers, that it should follow laws and regulations, and its goals:

> Wildlife management includes all mammals, birds, reptiles, and amphibians. Norwegian wildlife management should adhere to current laws and regulations and international agreements. The goal is to preserve species and their genetic diversity long-term, ensuring viable populations in their natural habitats.

The inclusion of all mammals is likely a clerical error; wildlife management does not encompass domestic animals, seals or whales. The goal is more interesting as it illustrates how the thinking has shifted from producing wildlife for recreational purposes to preserving biological diversity for the future.

We agree with Storaas and Punsvik (1996) that wildlife management is a targeted human effort to manipulate wildlife populations. The goals are political and can vary over time and space. It is definitely also wildlife management to try to mitigate conflicts between wildlife and humans, and we agree with Walker (1998) that wildlife management should be a learning process. We therefore propose the following definition:

> Wildlife management is a goal-oriented process involving actions and learning to influence interactions between wildlife, habitat, and humans to achieve desired outcomes in consultation with stakeholder groups based on the best available knowledge and practices.

GOALS AND CONFLICT IN WILDLIFE MANAGEMENT

The overarching goals of wildlife management are laid out in laws and regulations that provide its framework (see Chapter 4). Wildlife management goals may conflict with other sectors and stakeholder goals with regard to how nature and wildlife are managed. Stakeholders can be organizations, networks and individuals who:

1. Operate at the grassroots level where natural resources are managed and used.
2. Have active interests in the management of the specific resource.
3. Can be affected by resource management decisions.
4. Have power (e.g., political power, social influence or control over resource management) to support or hinder the implementation of measures.

These stakeholders can include nature managers and planners, municipalities and counties, local communities, nature resource-based industries, landowners and local interest organizations (Doyle-Capitman et al., 2018).

Not always do those who shout the loudest represent public opinion. The Norwegian state-owned forestry company Statskog perceived from meetings with hunters and media reports that everyone was very opposed to restrictions on grouse hunting in Nordland. When Breisjøberget et al. (2017) surveyed all hunters on state land, an overwhelming majority agreed to reduce their own hunting take to protect weak grouse populations. When at least 10,000 people with torches marched on the Parliament in 2019 in favor of liberalized wolf hunting and at least 7,000 demonstrated for protecting wolves, this indicates strong passion on both sides of this debate. At the same time, most of the over 5 million Norwegians did not march, though they might still have opinions, as it is a high threshold to join a march. Extreme opinions are often loudly expressed, and representative samples must be asked to understand what the general public really thinks about an issue.

Wildlife and nature conservation conflicts are between people who have different views on how to use nature. Skogen et al. (2013) states, for example, that it is no longer a conflict between people and wolves, but between people who want to protect wolves and those who want to eradicate them. Conflicts can be overarching, concerning such issues as greenhouse gas emissions or land use conflicts, or more specific issues such as the size of a moose population, hunting season duration and the methods and means of harvest (e.g., calibers and ammunition).

Greenhouse gas emissions leading to warming and possibly the extinction of the Arctic fox (*Vulpes lagopus*) in Norway (Pedersen et al., 2021a, 2021b) are a global challenge that also needs to be tackled in Norway. Until now, human land use has been the most significant driver of biodiversity loss worldwide (Chaudhary et al., 2016). Wildlife needs habitat, and often humans need the same areas for livelihood and recreational activities. Despite the Norwegian legislation embodied in the Nature Diversity Act and the Wildlife Act, it is challenging to prioritize wildlife and biodiversity when land-consuming developments can generate large revenues and provide green energy. Hydropower development submerges valleys with grazing land, blocks migration routes and opens the mountains with roads. Wind farms are industrial areas that occupy land; additionally, birds and bats are killed by turbines (Lloyd et al., 2022; May et al., 2019; Coppes et al., 2020; Gaultier et al., 2020). Offshore wind turbines can have a significant negative impact on long-lived, K-selected seabirds (Wright et al., 2020). Nevertheless, many wind farms are built before the effects on birds and bats or mitigation measures against collisions are known (Allison et al., 2017; Conkling et al., 2021). Wind turbines can contribute to a green shift and the survival of the Arctic fox. Balancing between habitat loss and preventing global warming is challenging.

Important and large transport routes consume a lot of land, habitats for animals can become fragmented and migration routes blocked. Major food production and self-sufficiency are important political goals. As a result, the most fertile areas are cultivated. While agricultural land can provide food for wild herbivores it displaces habitat for wild flora and fauna. Semi-domesticated reindeer herding displaces wild reindeer and large carnivores, which also struggle to survive in prioritized sheep grazing areas. Wild reindeer shy away from people, and their habitats are under significant pressure from development interests and other human activities (Punsvik & Jahren, 2006).

For new large projects, developers must assess the impact on wildlife (*cf.* the Norwegian Planning and Building Act[3]). Red-listed species can halt or relocate developments (Kvaløsæter, 2011). For common wildlife species, compromises are often sought. For new developments like the E6 international highway between Gothenburg, Sweden, to Lillehammer in Norway, wildlife is fenced out, but some overpasses and underpasses are constructed. For older roads that split wild reindeer areas, snow plowing may be avoided (Friisvegen between Atna and Ringebu), or parking along roads prohibited in winter (National Highway 27 over Venabygds mountain).

In 2005, nearly 80% of the Norwegian population lived in areas defined as urban, in cities and towns (Berg, 2005). National goals must therefore align with the wishes of the large voter base in urban areas. Skogen et al. (2013) pointed out that the highly educated middle class, which often supported international conservation goals, has been an adversary to rural people with local goals and attitudes. The feeling of being overruled by an elite regime can lead to dissatisfaction and protest movements among rural people.

It becomes more challenging to find suitable compromises when many people living in proximity to wildlife perceive only disadvantages with certain species. It can be tone-deaf to show more concern for a nuisance than for a neighbor experiencing loss. Rubino and Pienaar (2017) found, for example, that the cooperative climate was completely destroyed when local people perceived that authorities were much more concerned with the lives of rhinos than the lives of the local people in Africa.

Countries like Indonesia, the Democratic Republic of Congo and Brazil can earn more from logging than from preserving rainforests. Norway has tried to make preservation equally profitable through billion-dollar support (Regjeringen, 2022a). This aligns with the Malawi Principles under the Convention of Biological Diversity, which Norway recognizes.

Goal conflicts are often between different human interests, between what is beneficial for the environment or for developers. International conventions, national laws and regulations, and adopted plans set the framework for which wildlife management measures are relevant in Norway.

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3 https://www.regjeringen.no/en/dokumenter/planning-building-act/id570450/

MANAGEMENT BY OBJECTIVES

Management by objectives is common in public administration. Managers set goals, determine which measures should be implemented to achieve a goal, evaluate whether the goal was reached after measures are implemented and revise the approach if goals are not achieved. Wildlife managers have often had limited resources but much enthusiasm. A challenge for hunting management is that hunting rights usually belong to landowners on properties much smaller than the habitat of the wildlife populations, and many must agree on common goals, which can become imprecise since it is a democratic process. The result has often been that something has been done without allocating resources to measure whether the goal was achieved.

Measuring the impact of measures can be difficult. In Østerdalen, various measures, including feeding stations, were implemented with the goal of reducing the number of moose collisions on the railway by 50%. The collisions were reduced, but was this a result of the measures that were implemented? A tragic train wreck in January 2000 led to a complete cessation of train traffic during a short period. Clearly, this had nothing to do with the measures implemented. The following year, too many moose were again killed by trains, although far fewer moose were hit than expected given the cold and the length of the period with deep snow. Here, the goal was measurable; one could see if the collisions were halved. However, it had to be measured against the expected number of collisions given train traffic, snow depth, temperature and the length of the snowy winter (Storaas et al., 2005). To gain certain knowledge of causal relationships, one should generally set up experiments. Anyone could see many moose at feeding stations far from traffic routes. Nevertheless, it has been difficult to show that feeding led to fewer collisions. Large measures like feeding are rarely set up experimentally. The downside is that it is difficult to determine if the measure works.

It is important to distinguish goals from means. In moose management in the 1970s, it was important to stop shooting cows with calves and instead preserve the productive cows. A means to achieve this was to shoot calves instead of cows. This led to a heated debate where calf shooting appeared to be the goal. But shooting calves was not the goal; preserving productive cows and a productive moose population was (Andersen & Sæther, 1996).

In wolf management, it can also be difficult to distinguish goals from means. The goal could be to prevent livestock or dogs from being killed by wolves. One way is to shoot wolves. However, it might then seem that the goal for many is to shoot the wolf rather than to prevent depredations.

When there is great uncertainty in wildlife management, it has been suggested in recent decades to use the management approach known as adaptive management, a method that gathers knowledge and can flexibly change means while managing to achieve goals (see, e.g., Williams, 2011a; Organ et al., 2012a; Williams & Brown, 2014). Adaptive management (Chapter 8, p. 190) fits well with our definition of wildlife management.

ATTITUDES, NORMS, VALUES AND VALUE SCALES

Norms and rules change over time. Two years after the golden eagle (*Aquila chrysaetos*) was protected in Norway in 1968, author Storaas saw a notice offering a bounty for shooting the eagle outside the sheriff's office in Øystese, Kvam municipality. The rewarded action was overnight turned into environmental crime—without the sheriff realizing it. The general attitude had been that the golden eagle was a pest that should be killed. With the environmental awakening in the 1960s, the public attitude shifted to believing that birds of prey should be left alone. This change led to a new norm: protection. The protection did not come based on a benefit on an economic value scale, but there are also other value scales (Kellert, 1976). In this case, values on ecological, naturalistic, and moral scales trumped the negative values on the economic scale.

In a free economic market, prices are set at the intersection between the seller's demands and the buyer's willingness to pay. It is more difficult to set the value of things that are not traded. What is the value of a great tit (*Parus major*)? A strawberry grower who killed a magpie (*Pica pica*) in a rat (*Rattus norvegicus*) trap in 2017 was fined 18,000 NOK, later reduced to 10,000 by the district court. In several places, the magpie is given a negative value—there has been a bounty paid for each magpie killed—and discarded. The strawberry grower was not punished because the magpie was valuable, but for using an illegal trapping method outside the hunting season. It is difficult to set values on things that are not traded, such as the value of a national park, the view from a mountaintop or being able to drink water directly from a stream.

Heberlein (2012) shows the connection between attitudes and fundamental values. He also shows that we often do not act according to our own attitudes but rather follow the norms in society (see Chapter 3). Norms and rules can vary between countries. In some countries, all wildlife is protected while in others certain species can be hunted. The hunting rights may belong to the landowner or the public in a given country. Regulations vary regarding which hunting methods or means can be used or whether game meat can be marketed. Even within countries, views on how to treat wildlife can vary significantly.

THE ECONOMICS OF WILDLIFE

Wildlife can be sold three times. First, someone can either pay to experience it (e.g., moose safari), hunt it and/or buy the meat. There is a certain contradiction in that hunting can make wildlife fear people, while animals may learn that cars are safe and people on foot are dangerous. In Africa, showcasing wildlife is a major industry. In Norway, few derive income from this. The pricing of hunting varies greatly. Before 1899, small game hunting without a dog in Norway was free for everyone in all rural areas (Skavhaug, 2005; Østlie, undated).

Small game hunting today is largely about the experience, since buying hunting rights usually costs much more than the value of the meat the hunter takes home. However, the value of hunting rights for big game in Norway often approximates meat value if hunters manage to fulfill the quota. For big or small game, hunting properties in easily accessible, beautiful, wildlife-rich areas of Norway that provide good accommodations and guides will command higher prices.

In Norway, hunters and landowners have had a great interest in increasing small game populations for over 100 years, and various methods have been tried with varying success (Søilen & Brainerd, 1996). We see properties where hunting and wildlife management are professional, the hunting product is good and the activity provides jobs and income. But the usual practice is not to take measures for the wildlife, but only to manage hunters and hunting quotas. Small game depends on many factors to provide abundant populations during the hunting season; the usual practice is to harvest what nature provides—without investing anything in active management practices. In a sense, income from hunting is often regarded as a free bonus from owning land.

The cost of acquiring land and the rights to hunt and fish can still be high. In 2005, the 160 km^2 large and roadless Laagefjeld Common in the Hardanger Plateau National Park was sold for 111 million NOK. In the late 2010s, income from the property varied between 300,000 and 500,000 NOK. That's about 0.4% return on capital. It is clear that owning hunting and fishing rights in Norway has significant added value. At the next sale, it is expected that the value of this property will again increase considerably. The economic value of wildlife varies around the world depending on rights and culture (see Chapter 5).

ECOSYSTEM MANAGEMENT

Management was easier in the past when the goal was economically beneficial wildlife and profit. Author Storaas worked at the University of Idaho when President Clinton in the USA in 1992 decided that the American national forests should be managed with the goal of good ecosystem management, no longer just for economic profit and abundant game. The state forest managers came to the university to learn how to know if they were managing the ecosystem well. It is easy to measure economic output and how many deer are shot. It is difficult to know if the ecosystem is managed correctly. What is right in a system that is always changing? People can have different main goals:

1. Let the system develop with as little human impact as possible. One question then is what to do with alien species like mink that kill seabird eggs and chicks?
2. Try to recreate the ecosystem as it was before humans began to impact it. Should we work then for a new ice age in Norway?
3. Try to recreate an ecosystem as people shaped it at an earlier time. How can we recreate an ecosystem as it appeared in the 1950's, or the Viking Age?
4. Set measurable goals that are supported by the political majority and manage the system toward those goals. The purpose clause in the Nature Diversity Act states: "The purpose of the Act is to protect nature with its biological, landscape, and geological diversity and ecological processes through sustainable use and conservation …" This is now the overarching goal that we must strive to achieve as best we can.

AUTHORS' REFLECTIONS

The idea that something is natural can be used to assert that something, being natural, is right. The challenge is that it is very difficult to know what is natural. Is the natural state that Norway should be covered in ice, as it was for 12,000 years ago, or as it was in 1950, or as it is now? Is nature as it is now natural, or is nature now unnatural? Is it natural for humans to eradicate wolves, or is it natural for humans to let wolves return? Is it natural to cut down spruce and pine trees in their prime, or is it natural for trees to die of old age? Is it natural for sheep, which humans introduced to the country only 5,000 years ago, to graze on the open range in summer but stay indoors in winter? Are cities, forest roads or feeding wildlife natural? Was it natural when humans helped to eradicate mammoths, and is something that has happened since our species dispersed from Africa natural? It will probably be easier to use other more precise words than "natural".

Nature is changing. Evolution happens. Humans have evolved into a unique and dominant animal species through evolution. Species and life forms have died out, and others have developed. Nature moves forward. Humans impact all other species, directly or indirectly. Fortunately, people have developed ethical systems, which are indeed changing and vary in time and space. Ethics help us think about what is right and wrong, but different ethics can say that the same action can be right or wrong. Young Egil Skallagrimsson was praised by his mother when he killed a playmate (Heggstad, 1994). Today, this is no longer considered good ethics, not even in Iceland. In modern times, cooperating countries have developed international norms and conventions. A number of conventions have been developed to protect our shared nature. And it gives hope that 21% of Norwegian municipalities had coats of arms that featured animals, with 16% portraying different wildlife species[4].

Nature does not tell us what is right; nature follows its own laws with or without us. It is not easy to say what is natural, but we can set goals for what we find beneficial for us and the environment. These goals are set by politicians in Norway, after debates based on research-based knowledge along with the myths and beliefs of conflicting interest groups. The researcher can describe nature, find connections and predict what may happen with various interventions. The wildlife manager uses scientific knowledge to achieve the goals set by politicians in consultation with user interests. Often, one will not know what will happen with changes or new events; in such cases, managers must just base decisions on their best judgment relative to what is known. Wildlife management icon Aldo Leopold, who was very focused on science, called wildlife management an art; we must try to take wildlife management a step further and learn while we manage.

We authors have come to the conclusion that wildlife management is moving from an art to a science, but there will always be an element of art in it. The manager must base their work on scientific knowledge about nature, human values and attitudes, legislation, wildlife management in other countries and how wildlife can be influenced and monitored (Chapters 2–7). However, the manager and management body must exercise discretion in setting goals, measures and monitoring plans. Discretion has an element of art but can be drawn from art toward science by using methods from Chapter 8. The manager must build on scientific facts and theories that are testable and objective and that are based on knowledge that grows through the collection of data and research results. Nevertheless, it is an art to use knowledge and skills to achieve goals set for an area or wildlife population (Chapters 9–16). The art is to balance the conditions between humans, wildlife and the landscape to achieve these goals. In this way, science and art are two sides of the same wildlife management coin.

4 Before the reform of that reduced the number of municipalities in 2017.

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Scandinavian University Press.
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2. Wildlife and humans in Norway

Norwegians and Swedes share the Scandinavian Peninsula, with Northwestern Norway and Southeastern Sweden. The peninsula is partly isolated by the sea at the Northwestern edge of the Eurasian continent and is characterized by gradients from the warmer south to the colder north and from more humid oceanic climates in the west to the drier continental climates in the east. The growing season is generally short, and winter is long. Except for the former seabed, especially in Southern Sweden, little soil is suitable for cultivation, and where forests grow, they are resilient and regenerate after logging. Outside cities and towns, few people live per unit area. Nevertheless, all areas are significantly influenced by human activities—pollution, roads, power plants, power lines, forestry, livestock grazing, reindeer grazing, tourism, cabins, hikers, anglers and hunters. Even Swedish national parks without hunting and fishing are influenced by hikers, tourist cabins and domestic reindeer herding.

Wildlife populations follow ecological boundaries, not international borders. For example, the Norwegian Supreme Court considers wolves in Norway to be part of the Southern Scandinavian wolf population with its main distribution in Sweden (Norges Høyesterett, 2021). Wildlife management on one side of the border has consequences for wildlife management on the other. We view the Scandinavian Peninsula as a single wildlife area with two national management regimes (e.g., Liberg et al., 2010; Swenson & Andrén, 2005). In this chapter, we will discuss how people and wildlife came to Norway after the Ice Age and how humans impacted wildlife.

THE GREAT ICE MELT AND HUMAN MIGRATION

The climate varies and determines temperatures and the growing season. Even in recent times, winter in Norway has been a harsh period. Bull (1914) wrote, for example, that before timber rafting began, people in Rendalen worked hard during the summer. During the coldest winters, they mostly stayed indoors burning wood and eating the food they had gathered during the short three-month growing season. Winter is like a desert: the water is frozen and unavailable for plants. Nothing grows—people and wildlife must subsist on what was produced in the summer. The Vikings believed that before Ragnarok[1], there would be three winters without summers in between—the so-called Fimbul winter. This illustrates how important warmth and summer are for life in the north.

About 21,000 to 17,000 years ago, it was a bit colder in Norway. During summer not all the snow melted, and it accumulated and transformed under pressure from snow to ice. Near Umeå, at the center of the ice over Scandinavia, there was a 3,000-meter-thick ice layer (Grøndahl et al., 2010), and reindeer were the most important game in Southern France (Kuntz & Costamagno, 2011; Langlais et al., 2012).

As the climate warmed the ice melted and wildlife and people migrated north. In Scandinavia, the shoreline emerged as the ice melted. When the ice melted, two things happened: 1) The water level rose, and 2) the land rose. The land under the ice rose faster than the sea when the enormous ice melted. Therefore, we can see old shorelines inland in the fjords and find seashells far above the current sea level. In Southeastern and central Norway, the sea level was 200 meters higher than it is now (Grøndahl et al., 2010), and the water in Lake Mjøsa in Southern Norway was salty. The weight of the ice masses also had an impact far from the ice edge. When the landmass of what is now Norway was pressed down, the North Sea—without ice—was pressed up. When much water was bound in ice, the North Sea became dry land, known as Doggerland. When the land emerged, people moved in and thrived on terrestrial and marine wildlife (Bjerck, 2021).

During the Ice Age, mammals survived in refugia in Spain, Italy, the Balkans and Beringia in Asia (Figure 2.1). Humans and animals may have migrated to the Scandinavian Peninsula by at least three routes: 1) across the Norwegian Trench, which was a narrow fjord between Norway and Doggerland, 2) across the river that then separated Denmark and Sweden and/or 3) from Russia and Finland. They could have circumvented the ice to the north or east and entered when it melted. The genetics of reindeer (*Rangifer tarandus*; Røed et al., 2014), bears (Taberlet & Bouvet, 1994) and moose (Niedzialkowska et al., 2016; Wennerstrom et al., 2016) show that these species likely immigrated from both the east and south with genetic transition zones. Brown bears (*Ursus arctos*) may have survived in a continuous population that was later fragmented through persecution by humans, with subsequent isolation of subpopulations after the Ice Age (Swenson et al., 2011). It can take time for a species to colonize a new habitat and reproduce.

1 In Norse mythology, the term "Ragnarok" refers to a series of catastrophic events that lead to the destruction and rebirth of the world, similar to the Hebrew concept of "Armegeddon".

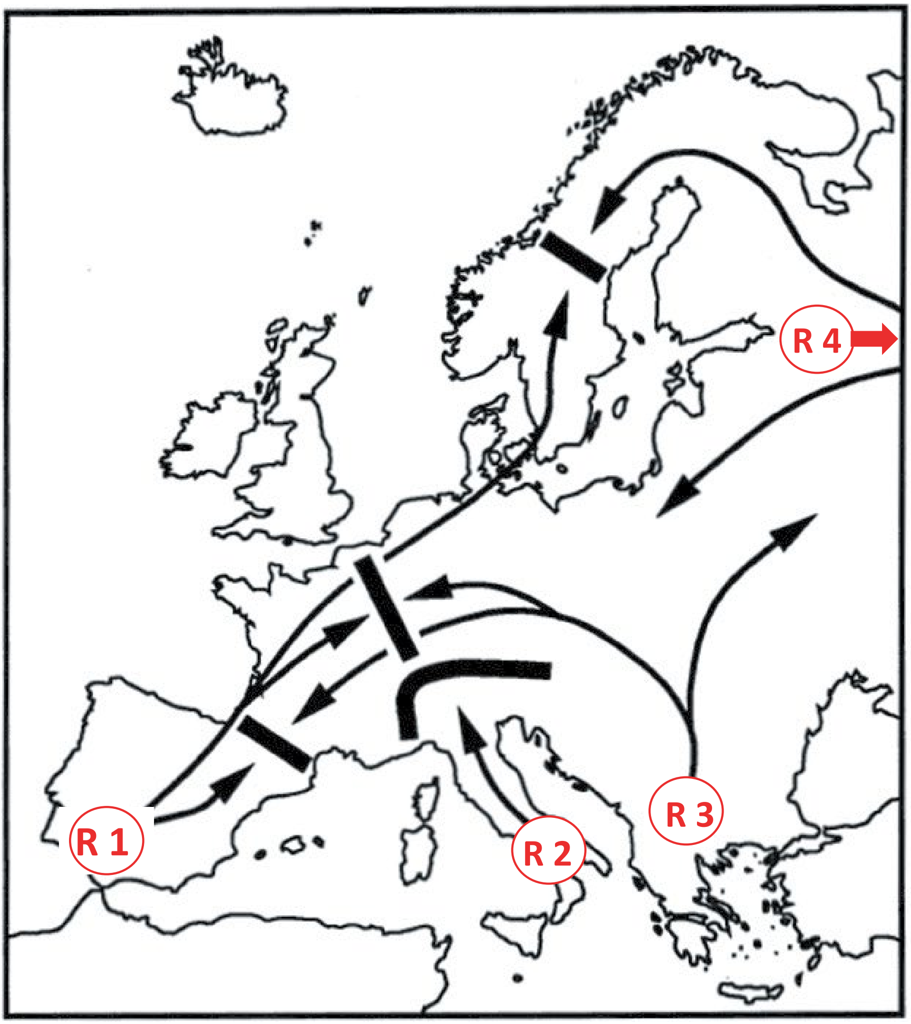

Figure 2.1: As the ice retreated, species could migrate from ice-free refugia on the Iberian Peninsula (R1), Italy (R2), the Balkans (R3) and Beringia (R4). Migration routes to Norway from the European continent were likely along the coastlines of Denmark and Sweden or from the east via Finland and Sweden. Adapted from Taberlet et al. (1994).

The oldest reindeer bones found in Norway are carbon-dated to 12,700–12,200 years ago (Table 2.1, Lie, 1986). Reindeer probably lived unperturbed by humans for several hundred years prior to our arrival, which was no earlier than around 11,700 years ago (Glørstad, 2013; Günther et al., 2018). People probably followed reindeer to Skåne in Southern Sweden (Bojs, 2017), while apparently maritime settlers colonized the Norwegian coastline (Bjerck, 2009).

Table 2.1: Timeline of events and the first evidence of migrations to Norway[2].

Year*	Event	Source
13,000 BP**	Ice cover	
12,500 BP	Reindeer	Lie (1986)
11,700 BP	Humans	Sources in Günther et al. (2018)
11,000 BP	Humans	Glørstad (2013)
10,300 BP	Moose	Grøndahl et al. (2010)
8,500 BP	Deer	Rosvold et al. (2013)
7,500 BP	Wild boar	Rosvold et al. (2010)
5,000 BP	Beginning of agriculture	Hjelle et al. (2006), Høgestøl & Prøsch-Danielsen (2006)
4,000 BP	Established agricultural societies	Hjelle et al. (2006)

* Years are rounded, ** Before present

Settlement in Norway likely began when people learned to make skinboats that could carry entire family groups and their belongings (Bang-Andersen, 2012; Bjerck, 2016). Most dwelling sites have been found along the coast (Glørstad, 2013). Small groups traveled along the coast, gathering shells, fishing, hunting marine mammals, and living in tents for short periods before moving on. Günther et al. (2018) have shown from genetic studies that people also likely arrived in Scandinavia via two routes: first from the south, then from the east on the north as the ice melted. Both migration routes align with the idea that people came to the Scandinavian Peninsula by boat. Especially those who came via the northern route consumed an extremely maritime diet. These groups mixed with each other (Figure 2.2, Günther et al., 2018).

Some more permanent dwelling sites have been found, often in caves and rock shelters and under overhanging cliffs. Some groups ventured inland to hunt reindeer (Bang-Andersen, 2012). Along the coast, for example at Fosnesstraumen, the catch shifted from predominantly fish, seals and otters (*Lutra lutra*) to cervids, wild boar (*Sus scrofa*) and birds during the transition from the Mesolithic to the Neolithic period over 6,000 years ago (Figure 2.3, Hjelle et al., 2006). Excavations at dwelling sites across western Norway show that moose bones were more common than red deer (*Cervus elaphus*) bones early on. Moose and wild boar bones have been found under Sævarhellaren in Herand in Hardanger, far from where moose and wild boar commonly occur today (Bergsvik & Hufthamar, 2009; Rosvold et al., 2013).

2 New discoveries may provide new dates.

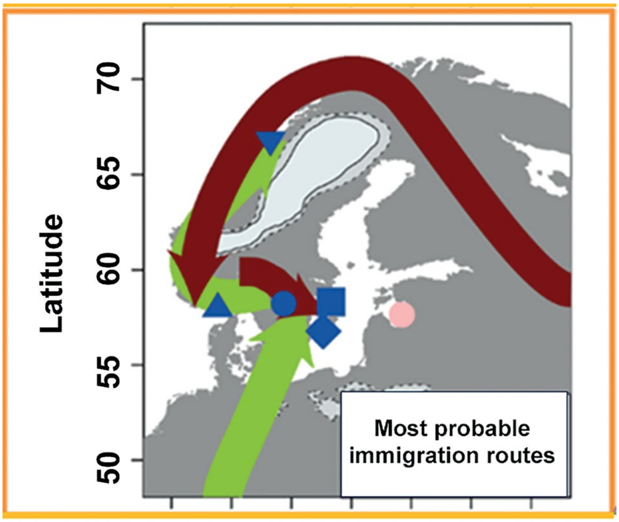

Figure 2.2: The most likely initial migration routes people used to reach the Scandinavian Peninsula. When the ice melted, hunter-gatherers followed wild reindeer to Skåne and perhaps a few over the border to Norway. When people learned to build boats, they sailed along the Norwegian coast from the north and south, likely meeting and mixing with one another. Blue and pink symbols show where DNA that the figure is based on has been found (Gunther et al., 2018; Bojs, 2017). Later, other people arrived, and Swedes seem to be descended from a mix of all these (Bojs, 2017). Adapted from Gunther et al. (2018).

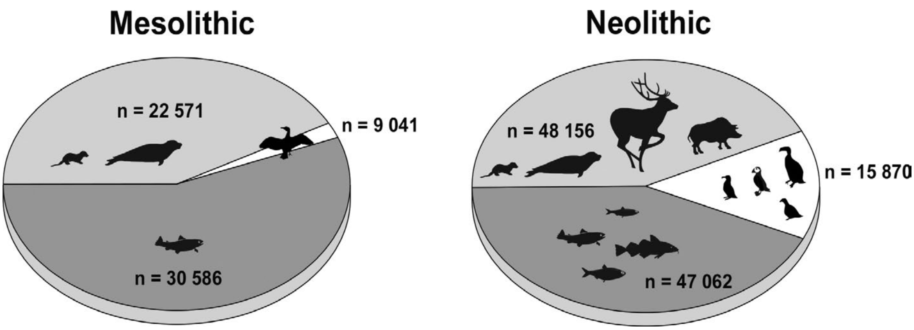

Figure 2.3: Distribution of bone fragments of mammals, fish and birds in the Mesolithic and Neolithic periods in Kotedalen west of Bergen. The transition between these periods is estimated to have occurred around 6,000 years ago. From Hjelle et al. (2006).

Agriculture could support over 20 times as many people compared to what hunting, fishing, and gathering could sustain in the same area. When agricultural cultures with many people arrived in new areas, they typically displaced hunter-gatherer cultures with fewer people (Diamond 1997a, 1997b). However, Bojs (2017) compellingly argues that early settled hunter-gatherers and immigrant agriculturalists who were originally farmers from Syria cohabitated in Southern Sweden for centuries starting around 6,000 years ago. In western Norway, it appears that the agricultural culture gradually grew over a long 1,000-year period. This suggests that hunters obtained a few domesticated animals, perhaps as status symbols, and eventually learned how to farm (Hjelle et al., 2006). Perhaps Norwegian agriculture was already so challenging in rocky and steep terrain that techniques for farming in marginal areas had to be learned and land cultivated before conquering agricultural peoples could manage to penetrate.

Around 4,400 years ago, a wave of light-skinned Indo-European herders likely came from the region between the Don and Volga Rivers. Hunters and fishers, who obtained enough vitamin D from their diet, could be dark-skinned, but for farmers with a more monotonous diet living far north, there was likely strong selection pressure for lighter skin that allowed sunlight to create vitamin D. Modern Swedes can often find genetic traces of hunter-gatherers, agricultural people from Syria, and Indo-Europeans from the east (Bojs, 2017; Lazaridis, 2018). Modern Norwegians have genes from many sources, including those present in prehistoric times, with links going back millennia (Kristjansson et al., 2021). Wee & Ellingsvåg (2023, p. 21) have shown that nearly half of ethnic Norwegians' genes come from the first hunters, fishers and gatherers. The Sami people also appear to be the result of women from the first settlers (Wee & Ellingsvåg, 2023) mixed with several waves of migration (Kristjansson et al., 2021), with one wave likely coming from the Volga-Ural region 2,700 years ago (Ingman & Gyllensten, 2007). With advancements in genetics, we will soon learn much more about the migrations of people and animals. Scandinavians, both Norwegians and Sami, have distinctive physical features but are mixes of various groups, all sharing common ancestry in Africa. This is worth considering when managing wildlife species to preserve specific genetic variants that might be more significant in our minds than in reality.

When the North Sea Land sank and the sea separated Denmark and Sweden, migration became more difficult. Most mammals likely migrated from the east along a route north of the Gulf of Bothnia (Figure 2.1). Migrating around the Gulf can be challenging and time-consuming for many species. Raccoon dogs (*Nyctereutes procyonoides*) were introduced to the European part of the Soviet Union as fur animals and invaded Finland, where they live off what they can find and kill. The raccoon dog hibernates and cannot survive if the winter is too long. Therefore, migrating north of the Gulf of Bothnia and into areas where they would thrive is somewhat challenging, and the Swedish raccoon dog project has successfully stopped this invasion (Dahl et al., 2016).

The partial isolation of the Scandinavian Peninsula can keep nature robust but also vulnerable to sudden invasive species. Red foxes (*Vulpes vulpes*) carrying mange (*Sarcoptes scabiei*) managed to get around or cross the Gulf of Bothnia in the 1970s, infecting Swedish foxes that were not immunoresistant (Mørner, 1992). Most red foxes (95%) died, but after 20 years, the population returned to pre-mange densities (Lindström et al., 1994). Likely, individuals who tolerated mange best survived and produced the most offspring (Soulsbury et al., 2007). The result of this rapid evolution is that red foxes and mange can now coexist as host and disease.

The climate has varied over time and can often explain the rise and fall of civilizations and migrations (Seland & Kleven, 2023). After the Ice Age, the climate warmed until about 5,000 years ago, when it again cooled. Subsequently, temperatures warmed again from 500 to 1300 AD until the advent of the Little Ice Age from 1300 to 1800 and many short cold spells. Now the climate is warming again. Which species thrive in Norway varies with the climate. In 2020, a golden jackal (*Canis aureus*) was discovered in Lakselv in the extreme northern part of the country. The golden jackal is a new predator, but since it arrived on its own, likely as a result of global warming, it was initially unclear how authorities would respond (Trouwborst et al., 2015). However, according to guidelines from the Norwegian Biodiversity Information Center, it should be welcomed, as it came naturally to Norway and was not introduced by humans.

MICROTINE CYCLES—THE ENGINE OF THE SMALL GAME ECOSYSTEM

A distinctive feature of boreal Scandinavia is the phenomenon of periodic microtine (*Microtinae*) cycles. Olaus Magnus (1555) believed that Norwegian lemmings (*Lemmus lemmus*) fell from the sky like swarms of locusts (Family Acrididae) and did not disappear until they had eaten all greenery and themselves died or were eaten by stoats (*Mustela erminea*). He wrote that this abundance of food during lemming years led to more and better stoat skins. Pontoppidan (1753) noted that lemmings appeared in enormous numbers every third to fourth year and speculated on the reasons why people had observed them falling from the sky like rain.

Many ecologists have been interested in identifying the causes of microtine population fluctuations. It seems clear that there are not just one but several causes or causal sequences. Andreassen (2014) studied microtines over several years in experimental systems where he and collaborators tested various hypotheses by manipulating habitat design, food availability and predation. He pointed to survival pockets and reproduction under the snow, effects of social mechanisms and predation, and explained the mechanisms in detail based on his interpretation of the experiments. Simplified, it can be described as follows: Microtine populations crash. Many predators starve or disperse, and microtines surviving in pockets thrive, causing populations to rebound. As microtine populations increase, predator populations also increase with this increased prey base, thereby stimulating reproduction and immigration. The numerous microtines face competition and stress; dominant males, who are most active, are taken by predators. When dominant males disappear, new males enter and kill offspring to mate with the mothers. Predation increases, microtine reproduction plummets, and populations crash again, repeating the cycle.

These waves of extreme variation in microtine biomass affect plant food sources and predators. Hagen (1952) introduced the alternative prey hypothesis in Norway, suggesting that predator populations, which grow during microtine years, switch to eating small game when microtine populations crash, transferring fluctuations in microtine populations via predators to small game populations. Many studies demonstrate this connection between microtines and small game (Wegge & Storaas, 1990; Breisjøberget et al., 2018; Hjeljord & Loe, 2022; Wegge et al., 2022). The relationship becomes stronger at higher elevations and latitudes (Bowler et al., 2020).

HUMANS AS APEX PREDATORS

Our activity as humans impacts all other species (see Ellis, 2015). Today, we are the apex predators to which even wolves, bears and tigers must be wary of (Ordiz et al., 2013). Many wildlife species exist now at our mercy. In the Stone Age, humans in northern regions were likely so few that they did not have a significant impact on most wildlife populations (Johnson & Miyanishi, 2012). However, some large, slowly reproducing species were still vulnerable to hunting. After the Ice Age, half of the large mammal species that lived in Europe disappeared (Barnosky et al., 2004). Hunting and trapping were the most likely causes of this (Varela et al., 2015).

Humans became even more significant to wildlife when agriculture spread from the south into the Nordic countries over a long period of about 5,000 to 4,000 years ago (Hjelle et al., 2006). From being dependent on game, humans subsisted on farming and hunting when wildlife was available. This gave humans a completely new opportunity to exterminate wildlife populations. As the population increased and fewer people needed to participate in food procurement, others could specialize as craftsmen, traders and weaponsmiths, and many more could modify habitats and participate in hunts at times of the year when it was beneficial.

Wild boar disappeared when agriculture became common (Hjelle et al., 2006), and moose bones vanished from middens in western Norway. People cleared the forests in the lowlands, and when moose hid on steep slopes they could easily be chased over cliffs. At the same time, the forest on the Hardanger Plateau disappeared as the climate became colder, and immigration of moose from the east likely became less common (Rosvold et al., 2013).

We have wondered about the significance of hunting for Norse settlements during the Viking Age. In the 9th century, Norwegian Viking Chief Ottar from Hålogaland told English King Alfred about trading trips to the White Sea for furs, skins and walrus tusks (Norgeshistorie, 2024). Furs and skins, obtained through hunting and trapping in northern areas (Birgisson, 2014), were valuable resources that could be exchanged for goods from agrarian societies (Baxter & Hamilton-Dyer, 2003; Richter, 2005; Fairnell & Barrett, 2007). Skins were particularly valuable, but reindeer meat and freshwater fish were also important export items from inner and Northern Fennoscandia from the 9th to the 13th century (Kuusela et al., 2020). The saga of Egil Skallagrimsson recounts that his uncle, Thorolf Kveldulfsson at Sandnessjøen, was killed by Harald Fairhair partly because Thorolf became too rich and powerful from collecting taxes and trading with the Sami. The works of Edda and Snorre-Edda from the 13th century tell of gods and heroes. In Hymiskviða, it is mentioned that the gods returned from hunting and wanted ale. Two gods, Skadi and Ull, were both gods of hunting and skiing. This suggests that hunting must have been somewhat important although it is not extensively documented.

People were able to create and maintain large, impressive pitfall trapping systems for reindeer and moose. When we look at these extensive systems today, one wonders how reindeer and moose survived at all. Genetic studies show that wild reindeer populations were reduced to a minimum by the mid-14th century (Røed et al., 2014). It became colder, and the Black Death in 1349–1350 killed half of the Norwegian population. As late as the 17th century, there were fewer farms in operation than before the Black Death. This led to minimal change in agriculture during this period. From the death of King Olav IV Håkonson in 1386 until 1814, Norway was under Danish rule. German Hanseatic merchants controlled fish exports and grain imports. Most Norwegians were poor and lived scattered, making it difficult to control the hunting of valuable wildlife populations. Taxes from the Sami were often paid in the form of furs. From 1100 to 1600, Finns paid taxes to the Swedish king in the form of furs (Pryser, 1987). In some Swedish Sami districts, all adult men in the 1500s had to pay three marten skins in annual taxes to the Swedish king (Tillhagen, 1987). In 1439, a cow was bought for two marten skins in Gudbrandsdalen (Pettersen 2013). In 1523, the value of a good cow was set at two marten skins in Sweden (Pryser, 1987). Helldin (2000) described how martens were nearly hunted to extinction in Sweden during a period of high demand for their fur and persecution as a predator of poultry. Few Sami lived off hunting and fishing in the north and in the inner mountain and forest areas until they switched to reindeer herding in the 1500s–1600s due to the lack of wild reindeer (NOU, 2007:14, p. 45).

One might think that decreased human population density and stagnation would be beneficial for wildlife. Thus, conditions should be favorable for kings and nobles who used hunting as a cherished pastime (see e.g., Høgh & Perto, 2011). However, in Norway, we see little evidence of this. Likely, wildlife populations were too small since the country is far north with scattered settlements of ordinary people who hunted intensively. The deposed Swedish archbishop Olaus Magnus (1555) had never seen a moose; he wrote about moose in his great book *Historia om de nordiska folken* based on old classical texts and mentioned that they had such stiff legs that they could not lie down as they would not be able to get up again.

Olaus Magnus also wrote that the capercaillie (*Tetrao urogallus*) was the most dangerous bird in the forest, even chasing the eagle away from its prey. The capercaillie took the prey in its claws and flew with it up to its nest in the treetop. Olaus Magnus had once tasted capercaillie during a visit to what he called the Tridentine Mountains but not in Sweden. Wildlife must not have been quite common. We have nevertheless seen large but varying exports of furs and skins from wildlife in lists from various customs records in the 18th century but have not found articles summarizing the data. The conclusion is that humans, even historically, have stood at the apex, transforming landscapes and suppressing wildlife populations through intensive hunting and trapping.

AGRICULTURE IN THE ANTHROPOCENE

When the Anthropocene (Crutzen, 2002) began around 1800 (Steffen et al., 2007), Norwegian and European landscapes were characterized by a long epoch with a management regime dominated by landowners, laborers and tenants in traditional agriculture (Jepsen et al., 2015). As the population increased throughout the 19th century, from nearly 884,000 in 1801 to nearly 1,700,000 in 1865 (Pryser, 2006), the pressure on new cultivation and grazing increased. Cultivated land in Scandinavia increased by 37% from 1875 to 1930, remained stable from 1930 to 1950 and decreased by 14% from 1950 to 1999. During the last period, cultivated land in Sweden decreased by 20%, but increased by nearly 10% in Norway (Li et al., 2013). Today, 3% of Norway (Ministry of Agriculture and Food, 2021) and 7.5% of Sweden are cultivated land (Tufte, 2021).

In the mid-1800s, 2.9 million livestock grazed on the open range in Norway (Søbye et al., 2004), 50,000 farms had summer pastures (Stensgaard, 2017) and 100,000 livestock were closely herded (Richardsen, 2012). Forester Jacob Barth (1881a) stated that summer pasture operations destroyed forests in the mountain valley of Valdres in Southern Norway. On the summer pastures, they produced cheese, which required firewood; when trees were cut for firewood, livestock kept new growth down by grazing. Barth wrote that these open areas were good for ptarmigan (*Lagopus* sp.) but destructive for capercaillie. Ungulate populations were low due to hunting, but livestock must also have consumed much of the potential ungulate forage.

Since 1907, the number of active summer pastures has dramatically declined in Norway. The number of farms with summer pastures fell to just under 1,000 by 2015 (Stensgaard, 2017). Since 1939, forage extraction from the open range has more than halved. Sheep, which can manage without cultural pastures, dairymaids or much herding, now graze roughly as before. Horses, cattle and goats, however, have almost disappeared from the open range (Moen, 1998). The common new livestock breeds are better adapted to concentrated feed than random range forage. Today, Norwegian dairy production is partly based on rainforests in Brazil being converted into plantations producing soy for concentrated feed (Løkeland-Stai & Lie, 2013). Sheep breeds that were bred to be herded in flocks were replaced by breeds that spread out in the terrain to find the best grazing plants. Livestock grazing in mountains and forests has decreased, and overgrown pastures and meadows have provided good forage for wild herbivores like moose. In recent years, grazing by beef cattle has increased.

Semi-domesticated reindeer impact approximately 40% of Norwegian nature. The number of these tame reindeer fell from around 100,000 to about half after World War II. Since then, the numbers have fluctuated significantly up to 180,000. In some districts in Finnmark, densities have at times been very high (Tømmervik & Riseth, 2011). Today, this reindeer population is around 215,000 (Landbruksdirektoratet, n.d.). While grazing from cattle has decreased, grazing from domestic reindeer has increased. Reindeer herding is mechanized with ATVs, snowmobiles and helicopters used whenever and wherever needed for economic reasons, and supplemental feeding with pellets during winter is common. Wild reindeer and wolves have been eradicated in reindeer areas, and the reindeer industry faces significant challenges from depredation by wolverines (*Gulo gulo*), lynxes (*Lynx lynx*), bears and golden eagles and miles of reindeer fences have been erected.

Domestic animals primarily graze on grass during the summer half of the year. Deer, on the other hand, eat both grass and browse on shrubs and must find food year-round. Grass tolerates very heavy grazing pressure because its growing points are close to the ground. Since the growing points in shrubs are in the buds and the growing points are grazed, shrubs can be much more damaged than grass is by grazing. Austrheim et al. (2008) showed how grazing pressure from grazers and browsers has varied through the ages (Figure 2.4). Before agriculture, browsing cervids used available forage alone; from around the birth of Christ, grazing livestock dominated. In recent times, cervid intake of plant forage has increased from 13% in 1949 to 55% in 1999. Forage intake has likely increased again due to beef cattle accompanied by calves. Cattle primarily eat grass, while moose are primarily browsers, but still avoid cattle (Herfindal et al., 2017; Wam & Herfindal, 2018). Usually, cattle forage in herds, resulting in high animal density where they are. In dense herds, cattle may also forage on leaves and perennials, even though this makes up a small part of the herd's diet.

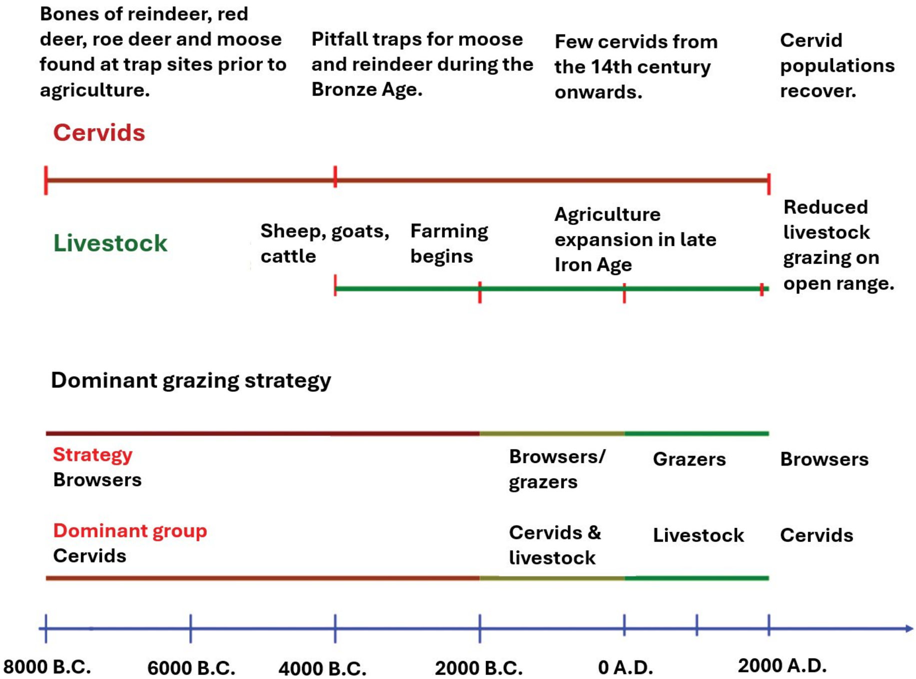

Figure 2.4: Timeline indicating how the dominant foraging strategy shifted between cervids (mainly browsers) and livestock (mainly grazers) in Norway. The figure is adapted from Austrheim et al. (2008).

In Fennoscandia, agricultural management regimes have developed from an era of innovations and rights to a stage of intensification and industrialization of production. Norway is still at this stage, while agricultural management in Sweden and Finland has further developed into an era of environmental awareness (Jepsen et al., 2015).

FORESTRY IN THE ANTHROPOCENE

As rafting techniques and systems developed, inland forests became valuable in Norway. Forest owners cut trees themselves or sold them to buyers. New forests grew from the remaining trees. The selectively logged, naturally regenerated forest was open, uniform and continuous and contained little timber. The forests were heavily logged and open, and production was low (Fryjordet, 1992). This type of forest was likely beneficial for bilberry (*Vaccinium myrtillus*) shrubs and small game.

Throughout the 20th century, planting became common after logging, and Norway spruce (*Picea abies*) was planted in deciduous forest areas in the west and north. After World War II, forestry transitioned to mechanized stand-based forestry. In 1945, forest work had to be conducted using manual labor by workers with horses. Today, one person in a machine can cut almost as much as 100 people could in 1950. Most jobs in primary forestry have disappeared. In stand-based forestry, forests are managed as different stands with relatively uniform growth conditions. Entire stands are typically logged, then planted or rejuvenated using seed trees (shelterwood) and soil preparation, scraping vegetation to provide better germination conditions for seeds. Stands are managed through thinning and spacing regulation until the next harvest. Timber production is much higher in managed forest stands compared to selectively logged forests over long periods.

There has been significant disagreement on how forestry impacts nature. Forest owner organizations have used the slogan "Forestry is nature conservation" to describe the dominant stand-based forestry. Others highlight the lack of biodiversity in industrial forests and dense spruce plantations. Stand-based forestry is primarily a successful method for providing raw materials to the forest industry but has simultaneously provided ample food for field voles (*Microtus agrestis*) and cervids in logged areas and young forests. Indirectly, this has provided more food for small and large predators by benefiting their prey bases.

In recent decades, the forestry industry has become more concerned with conducting forestry adapted to natural conditions and in accordance with the Nature Diversity Act (2009). Certification schemes aim to ensure biological diversity (PEFC Norway, 2022). Designated key biotopes should not be logged. There are also arrangements for voluntary conservation where owners are compensated for the loss by not logging. If we consider that it takes 100 years for forests to mature for harvest, around 1% of the forest is harvested annually. Few forest stands are older than 100 years, and there is little dead wood compared to primeval forests. There is a dense network of forest roads, which makes most of the forest and wildlife habitat easily accessible.

The European Union (EU) has developed a new forest strategy (European Commission, 2021). The strategy aims to facilitate and continue the important forest-based industry but increasingly emphasizes all the roles that forests can play, especially as carbon sinks and as habitats for biodiversity. The strategy stresses cooperation among many stakeholders, employing research to achieve goals, and lists many concrete measures, such as planting 3 billion trees in new areas. The strategy proposes a voluntary certification scheme, allowing buyers of timber products to know whether forestry products originate from stands managed for carbon capture and biodiversity goals. In 2022, parties of the Convention on Biological Diversity (CBD; Rio Convention, 1992) accepted an international agreement to protect nature. The agreement stipulates that within 30 years, 30% of all nature categories should be protected (Ministry of Climate and Environment, 2022). It will be interesting to see the consequences that this will have for Norwegian forestry.

Gjermund Andersen (2021) points to research and results from more varied forestry practices in, among others, the forests of Oslo municipality. Andersen describes a logging method called nature culture, which has reportedly provided better economic returns and captured more CO2 than traditional clear-cut forestry. Simultaneously, the forest still looks like a natural forest after logging. Gresh and Courter (2021) write that ecological forestry in Europe follows a trend called Close-to-Nature-Forestry, emphasizing the preservation of tree crowns so that the forest still appears as a natural forest after logging. They also note that forests are different, and the same practices may not be suitable everywhere.

Per Angelstam (1998) proposed the so-called ASIO model for how forests can be harvested and adapted to different natural disturbance regimes (Figure 2.5). ASIO is a Swedish acronym for different fire regimes in Nordic forests. In it, some forests historically never burned *at all* (A), some *seldom* burn (S), some have burned more *infrequently* (I), and others have burned *often* (O). Kuuluvainen et al. (2021) have further developed the model and demonstrate how forestry can be environmentally friendly based on different natural disturbance regimes. This allows for more varied forestry at different scales and with variations of stand-based forestry and selective logging. We believe that Kuuluvainen et al. (2021) point to a wise way to continue using the forest without significant disadvantages for either forest owners or biological diversity. Using wood for building materials will bind carbon for a time. However, a working group established by the Norwegian Environment Agency (Miljødirektoratet), Norwegian Agriculture Directorate (Landbruksdirektoratet) and Norwegian Institute of Bioeconomy (NBIO; Flugsrud et al., 2016) indicates some uncertainty regarding the possible climate effects of current forestry practices.

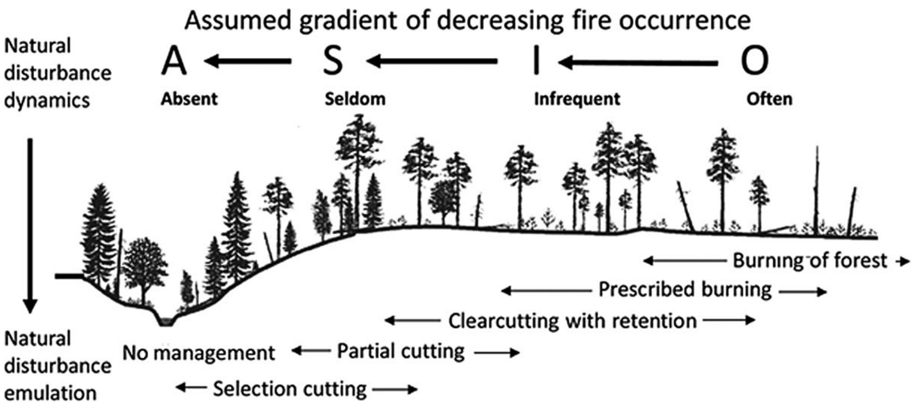

Figure 2.5: Illustrates the principle of the Swedish ASIO model (Angelstam, 1998). The landscape is divided along a moisture and nutrient gradient into four categories with different fire frequencies: **A** where it never burns *at all*, **S** where it *seldom* burns, **I** where it burns *infrequently*, and **O** where it burns *often*. The ASIO model shows how forests can be managed in different categories to most closely align with natural disturbance regimes. Natural disturbance regimes are how forests are rejuvenated before human impact. Adapted from Angelstam (1998).

URBANIZATION AND ITS IMPACT ON WILDLIFE

In 1910, over 60% of people in both Sweden and Norway still lived in rural areas. Due to different policies, urbanization began earlier in Sweden, but by 2000, nearly 80% of people in both countries lived in urban areas. Although the populations in both countries are increasing, over three to four generations, a large portion of young people have migrated to urban areas, and the rural human population has declined significantly (Berg, 2005; Elmhagen et al., 2015). In rural areas, women become mothers earlier and have more children, but these children move to urban areas (Kulu et al., 2007). After receiving education in the city, some move back to rural areas, having been influenced by urban values and norms. However, most take exciting jobs in urban areas and do not return (Sørlie & Juvkam, 2014).

Urbanization in Fennoscandia is different from the rest of Europe. The land area in Fennoscandia constitutes one-third of the land area in Europe, while the human population accounts for only 6–7% (Sørlie & Juvkam, 2014). The distances between towns are therefore much longer than further south (Sørlie, 2010). The peripheries—called thinning societies—are not abandoned but have fewer and older people (Aasbrenn, 1989).

The migration of people from rural to urban areas has had significant consequences for large and small game. If we read in the village book about the means of production a self-owning farming family in Hardanger relied upon over 100 years ago, we can understand that they tried to hunt any big game that wandered into their area. On a good farm with a wife, husband, seven children, a maid, a farmhand and elderly family members, they might have had six cows, a horse, 15 sheep, 20 fruit trees, and planted a barrel of barley and two barrels of potatoes, and they fished in the fjord. If they could harvest 60 kg of deer meat or 200 kg of moose meat, it would have had a significant impact on the welfare of the farm. Thus, moose and deer were quickly eliminated through unregulated harvest in such places, with only wild reindeer surviving in remote alpine areas.

Tillhagen (1987) writes extensively about the value of fur harvest in Sweden. To highlight one example, in the 1880s, a sawmill worker who worked 12 hours a day, six days a week, could earn as much from selling a single red fox skin as could be derived from two weeks' work. A marten skin was equivalent to three weeks' wages at the sawmill. Prices varied significantly, however; in some years, fur harvesters earned much more. In addition, they were paid bounties (Søilen, 1995). The intense hunting of fur animals led to the marten being eradicated from large parts of the country and needing total protection in 1930. The red fox was not eradicated, but it is reasonable to assume that the populations were significantly reduced, benefiting grouse and hare.

Sparse settlements of people with limited resources had major consequences for wildlife:

1. Much of the grazing resources were consumed by livestock.
2. Since people used the forests and mountains, they harvested big game they encountered.
3. A game animal slaughtered, whether legally or illegally, had a significant economic impact.
4. Red foxes or martens provided skins that were economically valuable.
5. Law enforcement was lax.
6. Predators were eradicated because they impacted livelihoods by killing livestock and game.
7. People lived scattered in forests and mountains where predators existed, making it easier to eradicate predators, especially after better firearms, traps and poisons were developed.

Migration to cities, increased prosperity, the development of synthetic warm clothing and changed attitudes have laid the foundation for an increase in many previously heavily hunted but adaptable wildlife species.

HABITAT LOSS AND FRAGMENTATION

In Norway, there is often a clear correlation between the reduction in area and the reduction in wildlife populations according to the Norwegian Biodiversity Information Center (Artsdatabanken, 2021b). Some species are entirely dependent on specific habitats. The great crested newt (*Triturus cristatus*), for instance, lives in small, shallow, permanent ponds without fish. If these ponds are removed, the newt disappears, and it also vanishes if fish are introduced[3]. Fragmentation leads to smaller, isolated populations (Dervo et al., 2021). On Dovrefjell, the migration route for wild reindeer between summer pastures in the west and winter pastures in the east was cut off by the construction of a railway and road. The population in the summer area is limited by access to winter pasture, and the population in the winter area is limited by access to summer pasture. As a result, far fewer reindeer can live in the two fragments than in the original herd range (Jordhøy, 2001).

Many have seen the figure showing how wilderness in Norway has diminished (Miljøstatus, n.d.). At the same time, wild reindeer populations have increased (Figure 2.6). Wilderness in Norway is defined as areas more than 5 km from infrastructure. If instead, the distance from areas with human economic activity were measured, the map would look different. Before World War II, all-natural resources were used in Norway with the technology and capital available at the time. Today, we can see traces of abandoned summer farms, small farms and crofts, as well as outbuildings where hay from isolated meadows was stored until sledding conditions were favorable. Leaves were important fodder for livestock, and deciduous trees were pollarded, i.e., cut high enough so grazing animals could not reach new shoots. Every five years, branches were cut during summer, and leaves and twigs were dried as livestock fodder (Garnås et al., 2018). Previously, vegetation was kept down in an open landscape that is now overgrowing (NIBIO, n.d.). The largest defined wilderness areas are in Finnmark, where modern, mechanized reindeer herding prevails at the expense of wild reindeer and wolves, which have been eradicated. With other definitions, we consider Finnmark less wild than areas without semi-domesticated reindeer now and in the past. The point is that all of Norway is influenced by long-term human use, but the pattern of use has changed.

3 https://lister.artsdatabanken.no/rodlisteforarter/2021/785

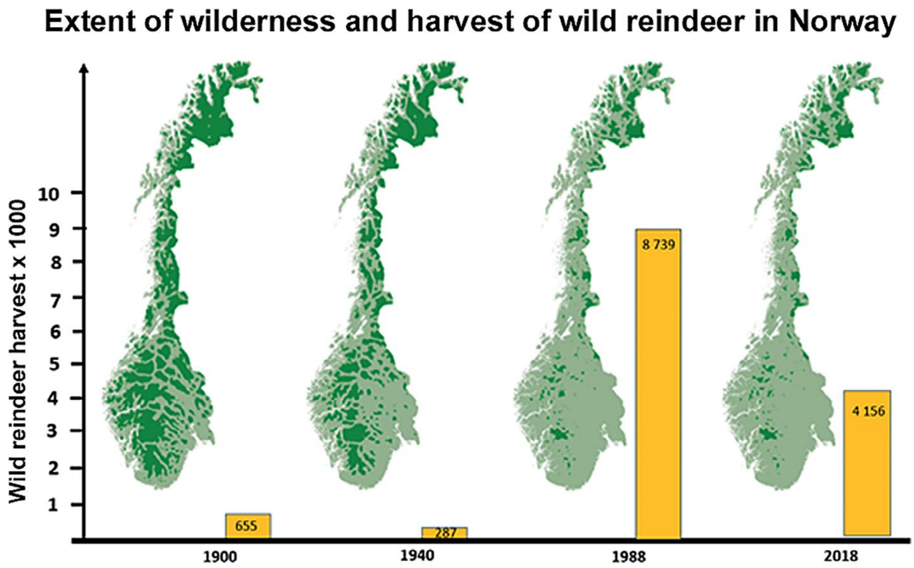

Figure 2.6: The dark green areas are more than 5 km in a straight line from major infrastructure. Wilderness-like areas have greatly diminished over time. Wilderness areas have been and are heavily influenced by grazing use; the largest wilderness areas in the north are tame reindeer herding areas with economically connected motorized traffic and strong limitations on predator populations. The columns show the culling figures for wild reindeer. Since there was no hunting in 1940, we used harvest data from 1939. Wild reindeer populations have grown while wilderness areas have decreased. Map from the Norwegian Environment Agency (Miljødirektoratet) and harvest data from Statistics Norway (Statistisk sentralbyrå, SSB)[4].

BIG GAME INCREASE—SMALL GAME DECREASE

Journalists and ecologists mostly report on negative developments, such as wild species that are threatened or endangered (see, e.g., WWF, 2022). Nevertheless, many common game mammal species are doing well in northern regions. Statistics Norway has records of cervid species harvested in Norway since 1889. Around the turn of the century, 1899–1900, only a few hundred moose, deer and wild reindeer were taken. The great hunter and forester Jacob Barth (1891) clearly stated that the willow ptarmigan (*Lagopus lagopus*) was the most important game species in Norway, both in terms of numbers and weight, even more important than the hare. This has changed. In autumn 2021, just under 30,000 moose and over 50,000 deer were culled, and there were more big game hunters than ptarmigan hunters.

4 www.ssb.no

After extermination (e.g., Hufthammer & Aaris-Sørensen, 1998), the first roe deer returned to Norway from Sweden around 1900. In 2021, nearly 35,000 roe deer were harvested. The wild reindeer population was so low that it had to be protected from 1902 to 1906. Before World War II, a few hundred wild reindeer were shot annually. We hear a lot about fragmentation and destruction of wild reindeer habitats. It may seem paradoxical that wild reindeer populations have nevertheless increased, and now a variable number of around 6,000 to 7,000 wild reindeer are harvested annually. This is, of course, because harvesting has become regulated and sustainable.

Large predators have made a comeback in Scandinavia. Sweden maintains predator populations that can likely survive independently and migrate into Norway. In Norway, politicians aim to keep populations at low levels with set targets for each species. When hunters cannot cull enough wolverines, the Norwegian Nature Inspectorate uses helicopters and snowmobiles to locate dens and kill pups and mothers. When snow conditions are favorable, efficient hunters generally succeed in culling lynxes, bears and wolves as permitted. The golden eagle is protected and no longer on the Red List. Large predators are back to the extent that elected officials allow.

For beavers and martens, recent times have been a success story. Both were nearly eradicated due to hunting and trapping for valuable pelts. Beavers were protected for the first time in 1845 (Rosell & Pedersen, 1999) and martens in 1930 (Helldin, 2000). Now, both species are common and huntable again throughout their range in Norway. Red fox populations have also increased. The number of red foxes culled rose until the sarcoptic mange epizootic began in the mid-1970s (Selås & Vik, 2006). Harvest statistics after mange cannot be used as a population index since hunting efforts have changed. Before the mange epidemic, many hunted intensively for valuable red fox pelts and bounties. Now, fur prices are low and red fox hunting is economically unattractive. If Selås and Vik (2006) are correct in attributing the increase to a larger food base from dead deer and hunting waste, then red fox populations must have risen significantly alongside the increase in cervid species after the mange epidemic. Wegge et al. (2019) estimated a density of 0.32–0.60 red foxes per km^2 in Varaldskogen in Southeastern Norway, and Lindsø et al. (2020) found an average of 0.1 fox per km^2 in a forest and mountain area in Lierne in central Norway.

For other small game species, the trend is different. Many ground-nesting bird populations have declined (Lehikoinen et al., 2019). Hjeljord (2015) and Hjeljord and Loe (2022) examined data from ptarmigan hunting from 1872 to today. It was challenging to find comparable data. They concluded that the best approach, despite all sources of error, was to look at how many ptarmigans each hunter shot per day. They show that yields varied greatly between years, even in older times, but until World War I, there were regularly very good ptarmigan years. From then until the 1970s, yields varied between poor and quite good. After the 1970s, there was a peak when mange in the red fox population appeared—otherwise, the high peaks disappeared. Hjeljord and Loe (2022) suggest that the main reason for the decline and loss of peak years is likely increased predation from martens and red foxes. The density of red fox and marten tracks on survey lines in winter was the best explanation for the degree of nest predation on capercaillie in various areas in Hedmark and Trøndelag (Jahren, 2017). Wegge and Rolstad (2023), after studying capercaillie and black grouse with various surveys and nearly 300 radio-tagged birds since 1980 in Varaldskogen east of Kongsvinger, conclude that capercaillie populations were kept low due to 50–70 years of forest fragmentation from clear-cutting, which increases deer and carrion (Needham et al., 2014), and thus boosted red fox and marten populations that were not harvested. Both willow ptarmigan and rock ptarmigan (*Lagopus mutus*) were temporarily listed on the Norwegian Red List as near threatened in 2016 (Kålås, 2015). The mountain hare is still red-listed. Broadly speaking, big game has increased significantly, while small game has declined considerably over the last century (Figure 2.7).

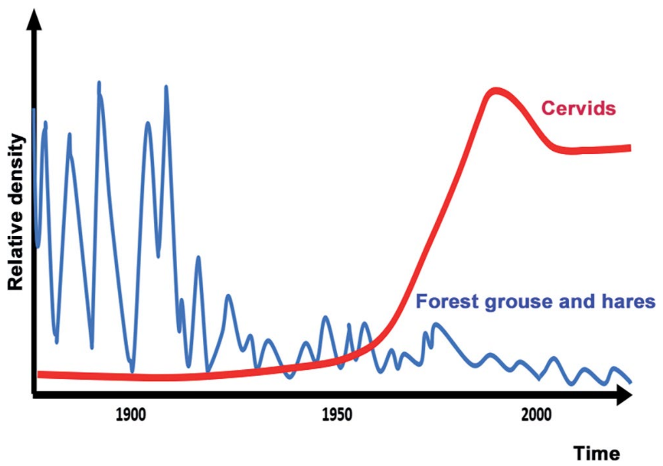

Figure 2.7: An approximate and simplified development of the species groups ungulates and small game. Yearly variations are much greater for r-selected small game than for more K-selected big game. Big game has increased, and small game has decreased.

In addition, many previously abundant seabirds are also now on the Red List. Species such as the razorbill (*Alca torda*), puffin (*Fratercula arctica*), black-headed gull (*Chroicocephalus ridibundus*), kittiwake (*Rissa tridactyla*), fulmar (*Fulmarus* *glacialis*), common tern (*Sterna hirundo*), common murre (*Uria aalge*) and thick-billed murre (*Uria lomvia*) are all severely or critically threatened for various reasons related to human activities.

UNEXPECTED EVENTS THAT CHANGE THE RULES

Wildlife species are evolutionarily adapted to what can be deemed normal conditions. Occasionally, something entirely novel and unexpected happens. Taleb (2010) introduced the concept of "black swans", meaning that something occurs that was completely unforeseen or thought of. Few consider that solar radiation could once again be reduced as it was in the year 536 A.D. after major volcanic eruptions that probably occurred in El Salvador and Indonesia. It became very cold, and possibly half of the human population of Norway and Sweden perished (Amundsen, 2018). The well-known explosion of the island volcano of Tambora in Indonesia in 1815 is another example. The entire top of the volcano exploded, turning to dust, and people in Europe starved because crops failed. Such unexpected events turn everything upside down and can completely change conditions for people and wildlife.

The Scandinavian Peninsula has been partially isolated from the lands further south since the sea entered between Sweden and Denmark. This means that diseases developed elsewhere, to which Norwegian wildlife do not have immunological resistance, could have a significant impact if they arrive here. Today, humans travel quickly and frequently. We bring dogs, cats and various livestock, while wild animals can arrive on their own. Despite countermeasures, it is reasonable to expect that Norwegian and Swedish wildlife will be exposed to new parasites and diseases that might thrive better with rising temperatures. It is difficult to predict in advance which diseases will come and when and what their impact might be on wildlife species.

In 2016, Chronic Wasting Disease (CWD) appeared for the first time in Europe in the wild reindeer population in Nordfjella between Hallingdal and Lærdal (Benestad et al., 2016). CWD is a prion disease that, strangely enough, cannot be adapted to since all genetic variants of reindeer die when infected. However, it appears that there is a difference in how easily different genotypes acquire the infection (Ytrehus et al., 2021). All reindeer in the Nordfjella zone 1 population were culled by the government. Nevertheless, CWD has been detected in a male and a female wild reindeer on the Hardanger Plateau. No one anticipated CWD would appear in Norway; this was a black swan that, if the disease spreads, could completely change big game management on the Scandinavian Peninsula. Potential black swans make it difficult to firmly believe in models predicting the future development of wildlife populations given such stochastic events.

The problem with black swans is that we do not know what will appear, but we must be prepared for everything to change in ways no one could have dreamed of.

AUTHORS' REFLECTIONS

In 2022, nearly 16 million people lived on the Scandinavian Peninsula along with 3,000 bears, 500 wolves, around 250,000 moose and over 2.6 million sheep. Swenson and Andren (2005) reported that most of the over 2 million sheep graze on the open range in summer, whereas the 450,000 sheep in Sweden are fenced in pastures. Conflicts between sheep farmers and large carnivores are high in Norway but much less in Sweden due to this difference in husbandry practices. Wildlife is completely subordinate and insignificant in the overall economy of Norway and Sweden. Norwegians and Swedes have experienced tremendous economic development that has transformed these countries. At the same time, wildlife habitats have been developed, fragmented, and migration routes blocked. Grazing industries eradicate wild reindeer and/or predators in defined wilderness areas. Our activities lead to rising temperatures, and new species arrive with our help and on their own. People have moved from rural to urban areas. Many see a boundary between where people live and the rest, which is perceived as wilderness, regardless of how many generations these areas have been used by people.

Cervid populations are much denser than before, and large carnivores are making a comeback. Small predators are thriving, while peaks in small game populations seem rare or have ceased. Increased populations of red foxes and martens appear to particularly suppress ground-nesting small game populations. The climate is warming, winters are shorter and some parasites have improved survival and are spreading. We expect that new and southerly species will grow and be competitive in Norway. It is difficult to precisely predict what will happen to people and wildlife. If CWD spreads and we continue to facilitate small predators so they can decimate small game, hunters in the future may need to focus on wild boar and red fox hunting. Global warming is a major challenge. We want nature to be natural. But what is natural in a world where conditions are changing? Nevertheless, we believe forestry can better mimic natural conditions if it is more adapted to the ASIO model. Regardless, all wildlife is subject to human priorities. Human priorities are often short-term. The most important thing for wildlife is how humans perceive it and what policies they choose to govern it by.

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3. The value of wildlife to people

Researchers and managers discovered that people's values and opinions were far more important than biological facts when making decisions that affected wildlife. Consequently, they developed a distinct discipline focusing on the human dimensions of wildlife and wildlife management, with dedicated scientific journals like *Human Dimensions of Wildlife*, first published in 1996. Understanding human values, attitudes and behavior is crucial for effective wildlife management.

In this chapter, we will discuss the development of ethical systems, how people view animals and the economic and societal value of animals. The chapter addresses various value scales and attitudes, beliefs and values. We will examine how norms vary over time and space and demonstrate that norms are often more important than attitudes in influencing behavior. To change people's behavior, it is useful to understand cognitive, technological and structural changes. The chapter also covers the wolf conflict, illustrating how values and identities clash. Previously, we valued animals based on their usefulness or harmfulness to people. Now, we list species on Red and Invasive Lists based on entirely different criteria, though we still consider harm and benefit.

We will discuss hunting in contemporary times when hunting for food is no longer necessary and ponder why kings and emperors hunted even though they did not need the food. The ethics of hunting and agriculture have similarities and differences, and wildlife management agencies can consider various stakeholder attitudes and values. Attitudes toward hunting vary between countries. Some advocate for ecological restoration. Researchers are sometimes mistrusted; they can choose to play different roles and must be clear about the roles they choose. The most important role for laypeople is to increase interest in nature and wildlife. We believe the content of this chapter is as important as the chapters on wildlife and conclude with thoughts on the choices humans make that determine the future of nature, wildlife and hunting.

ABOUT ETHICAL SYSTEMS

Since the future of nature and wildlife depends on how people think, we must discuss ethics and morality and how ethical systems might have developed. The word "ethics" comes from Greek, and "morality" from Latin, and both can be translated to "custom" in Norwegian. What is considered customary changes over time and space. Today, we think of ethics as the rules people should follow, while morality is the willingness to adhere to ethics.

Dawkins (1976) views humans as animals developed through evolution. He argues that individuals are survival mechanisms for genes. Individuals die, but genes can survive through offspring. He argues that humans need to learn a lot before they can manage on their own (Dawkins, 2008). He perceives many rules and religions as false appendages to useful information. Harari (2015), on the other hand, claims that a key reason for human success is our ability to believe in things that do not exist, to believe in abstract myths and values. By believing in the same myths, whether they are gods, money or societal systems, millions of people can cooperate and trust each other. This does not always benefit each individual but fosters cooperation, enabling large populations. Human rights, for example, are not universal rights that have existed at all times and places but were established by the United Nations in 1948 and are something we in Norway believe in and are committed to.

Regardless, we can observe the emergence of various beliefs and ethical systems. As long as most people believe in the system, it functions. Within these systems, it is common to operate with different forms of ethics. The literature on the subject is extensive. We choose to simplify the forms to 1) duty and virtue ethics, 2) consequentialism and 3) situational ethics. According to virtue ethics, you act correctly when you follow or strive to follow the rules out of a sense of duty. According to consequentialism, you act correctly when the consequences are good. Situational ethics are more flexible; you do what suits you and yours best in all situations. The development of our ethical systems is, in other words, crucial for how we view and behave toward nature and wildlife.

FROM ANTHROPOCENTRIC TO DIVERSE VIEWS ON WILDLIFE IN NORWAY

Wildlife management depends on how people view wildlife and nature. From sources around 1845, when the Norwegian Parliament passed the Act on the Extermination of Predators and Protection of Other Wildlife, Richardsen (2012) could not find anyone opposed to the eradication of wolves, bears, lynxes, wolverines, golden eagles, white-tailed eagles (*Haliaeetus albicilla*), goshawks (*Accipiter gentilis*) and eagle owls (*Bubo bubo*). The argument was that God had previously needed these predators to keep wildlife populations at the right level, but now humans were capable of taking over this role. This shows that the Norwegian people at that time seemed united in an anthropocentric view of nature, aligning with the traditional view of the church that nature exists for humans (Genesis 1:28: "Be fruitful and multiply, fill the earth and subdue it! Rule over the fish in the sea and the birds in the sky and over every living creature that moves on the ground.").

Today, the Christian stewardship thought dominates the church (Genesis 2:15: "The Lord God took the man and put him in the Garden of Eden to work it and take care of it." 1 Cor 4:1: "This, then, is how you ought to regard us: as servants of Christ and as those entrusted with the mysteries God has revealed."). The idea here is that Christians should manage God's creation for God. In the 2000s, the Church of Norway became engaged in nature conservation (Church of Norway, n.d.). Bishops have advised against oil exploration in Lofoten (Hovland & Weiby, 2009) and want to remove wind turbines in Fosen (Tveit & Eira, 2023), and the church has been criticized for being politically active (Hovland & Weiby, 2009).

Changes in legislation (Chapter 4) reflect how the view of animals has shifted from utilitarian to having intrinsic value, independent of their utility for humans (see also the Animal Welfare Act 2009, § 3). Now, Norwegian legislation is characterized by the stewardship principle; all wildlife is protected and can only be harvested when populations can tolerate it. Consumptive use organizations support this, but strong international organizations have emerged that want to abolish livestock farming, ban hunting and advocate for everyone to eat plant-based food (see, e.g., Regan, 1983; Singer, 2009, 2016). In Norway, the animal protection organization NOAH works in line with these views for animal rights. The organization believes animals are not for human exploitation. They work for a society where animals have rights and where the power to exploit does not confer the right to exploit either domestic or wild animals.

THE ECONOMIC VALUE OF WILDLIFE

Economic value can be seen as the meeting point between the price someone is willing to sell for and what someone is willing to pay for the same. Thus, we can measure the economic value of skins, viewing wildlife, hunting wildlife and wild meat. In some cultures, wild animal skins had such high value that they were used as currency. In Russia, sable (*Martes zibellina)* skins were used as a currency in the 1500s (Etkin, 2011). In Croatia, the currency was called kuna ("marten") from 1994 to 2023, based on the historic use of marten pelts as currency, and is now represented on the €1 coin representing that country[1]. Olaus Magnus (1555) mocked Russians for using sable rather than gold, arguing gold was more durable. In Canada, the value of all goods to the Hudson Bay Company was converted into the number of beaver skins, which served as the currency (Carlos & Lewis, 2001).

1 https://www.ecb.europa.eu/euro/coins/html/hr.en.html

The value of beaver and marten skins was so high that the species were nearly eradicated from Scandinavia—they had to be fully protected (Helldin, 2000; Halley et al., 2012). Today, trade in living and dead specimens of protected wildlife species is considered a major threat to biodiversity (Challender et al., 2015). The trade is believed to be large and extensive, but since it is illegal, it is difficult to know precisely how widespread it is (Blundell & Mascia, 2005). Collectors are willing to pay substantial sums for rare specimens and species. The greatest pressure on animal species can occur when millions believe medicines containing ingredients from a species can cure dangerous and bothersome diseases. In 2013, the black market price per kilogram of rhino horn was higher than the price of gold (Chapter 5, p. 135). It can be more challenging to measure the value of living rhinos where they are protected. We can ask people what a free-ranging wild rhino is worth, but Heberlein (2012) references work showing that there is often a discrepancy between what people say something is worth and what they are willing to pay.

It is somewhat easier to calculate the economic value of big game. Storaas et al. (2001) analyzed the costs of producing an extra moose and the consequences this had for various stakeholders (Figure 3.1). To harvest one additional moose, typically three extra moose need forage throughout the winter. If they have difficulty finding forage, they may wander and cross roads. These three extra moose could lead to increased browsing damage and more traffic accidents.

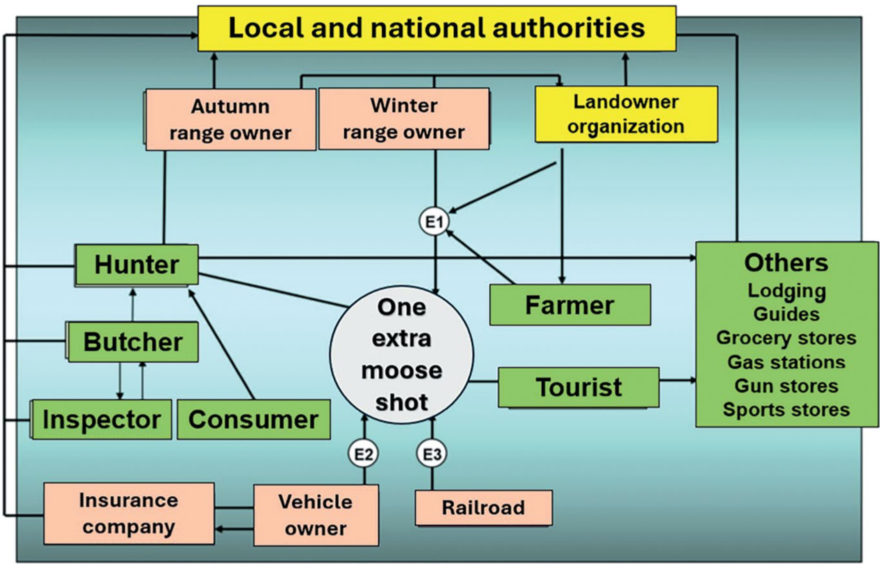

Figure 3.1: Sketch of the economic consequences of increasing the moose population to harvest one more. Green indicates potential gains, red indicates potential losses. Arrows show value streams. E1–E3 are measures that can be implemented to minimize disadvantages (Storaas et al., 2001).

For the extra moose, the hunter must pay the landowner for a hunting permit. The landowner can also charge for meat, experiences, accommodation, and services but must pay a felling fee to the municipality. More moose permits in the area could also lead to more hunters, increased supervision and enforcement, and more sales of sporting goods, hunting dogs, four-wheel-drive vehicles, good hunting food in local stores, more gasoline, overnight stays, tolls and dinners. If the hunter harvests the moose, the meat can be sold. The meat inspector can charge a fee, and the value of the meat can be increased if the shooter or butcher processes it, and stores can profit from selling it.

The cost involves having three extra moose in the forest throughout the year. If the forage requirements of the moose population are low compared to the forage availability, there is no cost to the forest owner. In fact, moose browsing could spare the forest owner the costs of forest clearing. If forage needs and availability are more balanced, three extra moose will require additional forage. This can be met with forestry measures that provide more forage. Before winter feeding was banned in 2016 (due to concerns regarding the spread of CWD), the three moose could be fed with six round bales. Moose eating silage from round bales in peripheral valleys are not as vulnerable to collisions with vehicles as they are along the main road corridor between Oslo and Trondheim (Riksvei 3). If the population was not too large for the nutritional basis initially, the income from an extra moose would correspond to the value of hunting one moose minus the cost of six round bales. A challenge is that round bales do not contain complete forage, so moose graze heavily around feeding stations. Another challenge is that the owner of good fall areas receives the income from moose hunting while feeding or other forage measures must occur in winter areas.

Wildlife can have both negative and positive value for various stakeholders. When wolves returned to Eastern Norway, they had different implications for different groups of people. Livestock owners lost animals, and sheep farmers stopped using forest pastures in wolf territories. Those who immediately ceased sheep grazing generally did not receive any compensation. Those who persevered mostly had their losses or grazing areas compensated; authorities believe livestock owners received good compensation, but livestock owners often feel the compensation was inadequate. Economic losers included landowners who received less income from hunting in wolf territories (Pedersen et al., 2019). This has been minimally compensated, as the principle has been that the government should not compensate for losses when wild animals kill wild animals. As a result, those few with wolves on their land incurred losses that others elsewhere did not experience. Researchers have sought and received funding to study wolves, people and conflicts. Research institutions have received funding to monitor wolf populations. The Norwegian Nature Inspectorate (SNO) receives funds for monitoring and killing wolves where they are not supposed to be outside of the wolf management zone. Members of large carnivore management boards are paid for participating in interesting and challenging work. Some hunters find it exciting to participate in legal predator hunts. Participants in municipal culling teams are paid to join predator hunts.

Wolves, however, are much more than just an economic issue. Livestock owners are compensated for their losses to wolves. Nevertheless, several mayors in 2017 refused to accept money the government allocated as compensation to municipalities for the inconveniences caused by wolves (Strande & Næsheim, 2017; Vespestad & Kessel, 2017). Stor-Elvdal municipality pragmatically used such funds in 2019 to compensate landowners for losses of moose to wolves (Sandberg, 2018). The fact that Prime Minister Støre's administration removed wolf subsidies to municipalities in 2021 (Brandett, 2022) suggests that the government saw the political gain as too low or that the Center Party, the farmers political party, then sharing power wanted to maintain conflict to reduce the number of wolves.

SOCIOECONOMIC VALUE

In addition to looking at direct monetary transfers, economists consider the socioeconomic value of various activities. Menon Economics (Pedersen et al., 2020; Table 3.1) examined the socioeconomic value of moose hunting in Norway during the 2019/2020 hunting season. They calculated the meat value, the recreational value and the health benefit value from the physical activity associated with moose hunting. They found the meat value by multiplying the number of moose culled by average weight and an assumed price per kilogram of 65 NOK. They also surveyed to determine the consumer surplus, which is the maximum additional cost hunters would be willing to pay to continue hunting moose. The greatest value they found was the value of increased physical activity leading to better health. They write that the calculation is uncertain, but they arrive at an estimate of 1.1 billion NOK. Thus, the Norwegian moose population represents a capital that yields an annual return of 1.1 billion NOK.

Table 3.1: Calculated socioeconomic value of moose hunting for the 2019/2020 hunting season in million NOK (Pedersen et al., 2020).

Norway Total	Total Value (NOK)
Recreational Value (A + B + C)	267
A – Social Community	90
B – Experience	81
C – Excitement of Hunting	95

Norway Total	Total Value (NOK)
Value of Increased Physical Activity / Health	615
Meat Value	253
Total Socioeconomic Value of Moose Hunting	1,135

*Based on the number of moose hunters from Statistics Norway (SSB) and meat volume from the deer register for the 2018 hunting season.

VALUE SCALES

A swift (*Apus apus*) in the sky or a great tit at the bird feeder has no place in any economic system but still holds value for many and under the law. Kellert (1976, 1984) began measuring values on other value scales and attempted in his book *The Value of Life* to assign values to life (Kellert, 1996). He wrote extensively about nine different fundamental values that nature can have. Thus, one natural phenomenon can be valued by different people on nine value scales. Vittersø et al. (1998) simplified this to six value scales in Norwegian surveys and defined them as follows:

1. **Dominant**: Interest in mastering, controlling and dominating animals.
2. **Ecological**: Interest in the ecological value of species and how species and environments affect each other.
3. **Moralistic**: Opposition to mistreatment and harming of individuals and species.
4. **Naturalistic**: Interest in direct contact with species during outdoor activities.
5. **Utilitarian**: Interest in using species or their habitat for practical purposes.
6. **Negative**: Fear, dislike or indifference toward species.

The definitions by Kellert and Vittersø are slightly different. We might also include Kellert's symbolic value scale if we were to determine Norwegians' views on nature. The important thing for us is to know that there are many other value scales besides the economic one. We believe that a large part of those who study ecology and nature management are more concerned with how phenomena score on the naturalistic and ecological scales than on the economic scale.

Kellert (1996) measured how different groups scored on various scales. He compared the views of different nationalities and American occupational groups, age groups and genders. People with different levels of education scored differently on the various value scales. The differences are striking. People with little education scored high, whereas those with much education scored low, and vice versa. The question may be whether the value basis changes through education and being in an educational environment, or if Americans who pursue higher education come from specific social strata. It might be that with higher education one learns that the world is complex—and that simple solutions are not always so simple.

In the Twin Cities, Minnesota, city dwellers scored high on ecological, moralistic and naturalistic scales, while they had little knowledge about wolves and did not want them to be culled (Figure 3.2). Farmers wanted to dominate and harvest wolves, were very negative toward them and had average knowledge about wolves. Trappers wanted to dominate, were less moralistic, scored high on naturalism, were positive toward wolves, wanted to trap them and had much knowledge. Trappers, who killed and wanted to kill wolves with legal foothold traps and snares, were the group most positive toward wolves and might be an example of those who benefit from harvesting wildlife also being positive toward the wildlife.

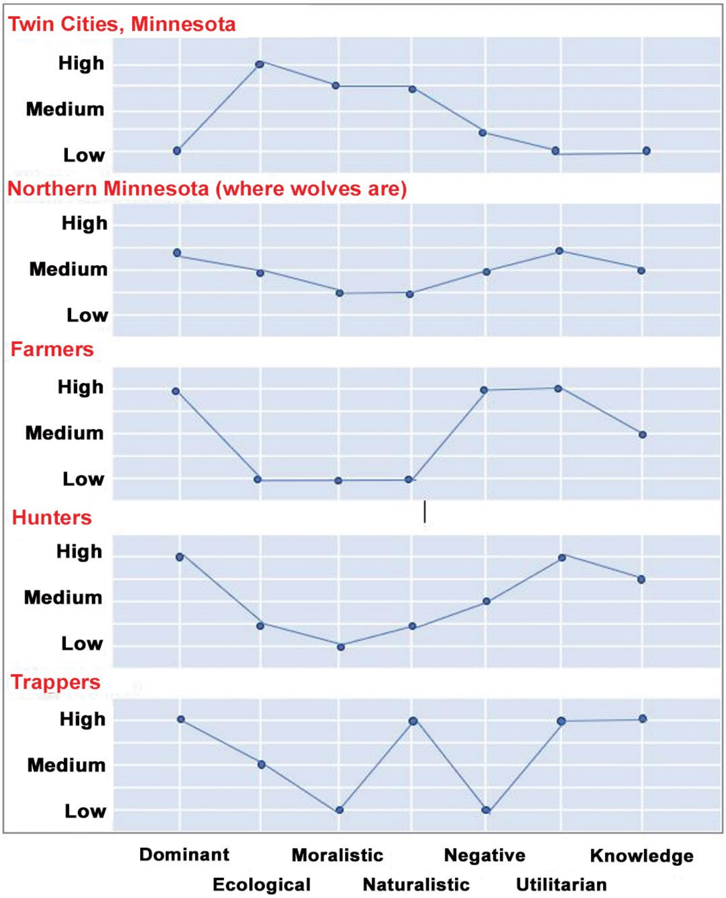

Figure 3.2: Attitudes of different groups in Minnesota toward wolves measured on seven different scales (Kellert, 1996).

In the 1990s, Norway worked hard to get other countries to accept its whaling practices (e.g., St.meld. nr. 27 (2003–2004)[2] on marine mammals). The Ministry of Foreign Affairs aimed to convince people in other countries that Norway's minke whale hunting was ecologically sustainable. If hunting was sustainable, everyone should understand that whaling was good. However, Kellert (1996) had already asked people in different countries whether they would accept whaling if it was biologically sustainable. In Norway and Japan, an overwhelming majority thought it was okay. In the USA and Australia, however, 70% and 80% of the people, respectively, were against whaling regardless of how biologically sustainable the harvest was. They believed whales should swim freely and not be harpooned. If Norway convinced them to understand that hunting was sustainable, it would not affect their opinion on whaling. The money from the Ministry of Foreign Affairs was probably entirely wasted because the argument was irrelevant to the target audience. Whaling in the USA and Australia was discontinued long ago, and the whaling culture there was long gone (except among indigenous peoples in Alaska and other coastal areas).

After Kellert's foundational work on incorporating value scales into nature management, attitudes and values have become a significant research field with various definitions. Heberlein (2012) uses values such as "taking care of the family," "using natural resources is important" or "preserving nature for future generations is important." Drijfhout et al. (2020) refer to authors who say that underlying values like nature-centered, human-centered and self-centered can predict attitudes and behavior toward nature. She also adds an animal-centered value. People usually have relatively few fundamental values, and attitudes and norms vary greatly over time and space and between different societal groups. Values are based on myths and beliefs in the respective societies (Harari, 2015).

ATTITUDES, BELIEFS AND EVALUATED BELIEFS

Many nature and wildlife management projects have failed because proponents did not understand how people's fundamental values and attitudes are interconnected, how difficult or time-consuming it is to change attitudes, and that norms often override attitudes (Heberlein, 2012). For example, informational campaigns were launched about wolves that started returning to Norwegian nature around the turn of the millennium. The idea was that if people gained knowledge about wolves, they would lose their prejudices and become positive

2 https://www.regjeringen.no/no/dokumenter/stmeld-nr-27-2003-2004-/id404057/

toward wolves (Svenningsen & Skogen, 2003). However, knowledge does not necessarily lead to positive attitudes. It turned out that hunters in wolf areas in Sweden had both the most knowledge about and the most opposition to wolves (Ericsson & Heberlein, 2003).

Heberlein (2012) shows that our values are fundamental to our attitudes. We observe the world and form a cognitive picture of what we observe, which Heberlein calls a belief. Beliefs are tied to objects, are absent of emotion, and can be defined as "facts as people perceive them" (Dietz et al., 2005) but may not be necessarily correct. An evaluated belief is a belief colored by our basic values. Such evaluated beliefs imply that one alternative is better than another. Based on our evaluated beliefs, we form attitudes. Attitudes are always directed toward something—such as hunting or wolves. In Tables 3.2 and 3.3 adapted from Heberlein (2012: Tables 2.1 and 2.2) we present a model connecting these concepts using the example of attitudes toward wolf management in Norway. In the vertical structure (Table 3.2), the fundamental value is the protection of nature, with beliefs that wolves are native and wild to Norway. The evaluated belief states that wolves belong (rather than not) in Norway. The attitude that wolves should be allowed to live in Norway is at the top of this conceptual structure.

Table 3.2: Vertical structure showing the relationship between value, belief, evaluated belief and attitude (with a hypothetical Norwegian example based on Heberlein's system (2012, Table 2.1)).

Attitude	Wolves should live		
Evaluated Belief	Wolves belong in Norway		
Belief	Wolves are native fauna	Wolves are wild and free	Vertical structure
Value	Nature should be preserved		

If an attitude is based on a network of values, observation-based beliefs and evaluated beliefs, the attitude is very firm (see Table 3.3). Heberlein (2012) shows that attitudes are often overridden by societal norms and rules; thus, people's behavior may not reveal their attitudes unless they break norms or even laws.

Table 3.3: A horizontal structure illustrating various values, beliefs and evaluated beliefs can explain a negative attitude of local people toward wolves in Norway, [Based on Heberlein (2012; Table 2.2.)],. underlying values, beliefs, evaluated beliefs and attitudes [with a hypothetical Norwegian example based on Heberlein's system (2012)].

Attitude	I don't want wolves where I live											
Evaluated belief	It is terrible that people no longer pick berries		It is sad that people can no longer hunt with dogs		It is unfortunate that sheep are no longer grazed on the open range.		I don't like having less game to harvest		I dislike that my friends lose their livelihoods		I dislike city folk deciding for me	
Belief	Folks are afraid of wolves	Children no longer go in the woods	I love my dog	Wolves kill dogs	Wolves kill sheep	Farmers quit grazing sheep.	Wolves kill big game	A lot of good game meat is lost to wolves	Sheep can no longer be grazed on the open range	Friends lose income from leasing hunting	City people decide what happens here.	Highly educated people decide for me.
Value	Nature's wealth should be used		Family safety Nature should be used		Utilitarian culture Public safety		Utilitarian culture		Empathy with neighbors		Independence	

Attitudes are generally difficult to change. Heberlein (2012) points to research showing that attitudes can change under certain conditions:

1. **Opinions:** An attitude based on few values is more like an opinion. Opinions are often somewhat random and can be changed through good argumentation.
2. **Strong experiences:** Having a strong experience that shows one was wrong. Media reports have mentioned people who were originally positive toward wolves until one killed their dog, at which point they became negative. Such strong, direct experiences can lead people to change their identity and attitudes.
3. **Educational environments:** Attitudes can also change when one is in special, often isolated, educational environments where teachers may have a strong influence on people's values.
4. **Association with other attitudes:** Attitudes can change if they are linked to other attitudes. If opposition to wolves is associated with losers in rural areas, people may choose not to be against wolves to avoid being seen as rural losers. If opposition to wolves is associated with resistance to centralization and urbanization, people may be against wolves to show support for local and regional interests.
5. **Generational change:** The old die, and the young have different attitudes because they grew up with different impressions and influences. The well-known Norwegian hunter Dag Hallgrim Bakka often says that the best thing about old moose hunters is that they are old. He believes they have so many strange attitudes that it is good they will soon pass away.

People often do not act in accordance with their attitudes and can hold conflicting attitudes. Author Storaas has written in two books (Storaas & Punsvik, 1996; Punsvik & Storaas, 2002) about the importance of preserving wild reindeer alpine ranges in Norway where his attitude is that such areas should not be developed piece by piece. Later, he sat on municipal planning committees and voted for such development to promote jobs and welfare but voted against it again when he was elected to the wild reindeer board and saw the overall pressure on the wild reindeer mountains. Politics often involves compromising one's own conflicting attitudes and underlying values. Heberlein (2012) points out that attitudes tend to be consistent, but not always. Attitudes associated with our emotions can be difficult to change unless our roles and identities also change.

Heberlein (2012) shows that advertising campaigns rarely influence attitudes or change behavior. Advertising affects the debate and what is discussed, but campaigns have little impact on strong attitudes that are based on many beliefs and values. One example is the fight against tobacco. As early as the 1950s, research clearly demonstrated that tobacco was harmful to people. Only after 50 years and various bans and practical measures against tobacco use have public attitudes toward smoking become mostly negative.

NORMS IN TIME AND SPACE

How people behave is often more important to others than what they think. Even if people do not need to agree with norms, they usually follow them. Violations of norms have consequences—often just condemnation—but when laws follow norms, it can lead to prosecution and punishment. However, just because people follow certain norms does not mean they believe such norms are right.

Norms for acceptable hunter behavior in Norway have undergone significant changes in recent decades. In the 1970s, large bags and long shots were something to brag about. If a hunter shot three reindeer with one bullet or a running reindeer at a 200-meter distance, it was considered a stroke of luck that everyone admired (Vaa, 2012a, pp. 173–174). Today, the shooter is punished for such actions due to the high risk of wounding an animal. If someone now shoots many ptarmigans, they may be publicly shamed in the media as unethical and greedy.

The norm for construction in wild reindeer areas has also changed. Previously, such developments, including roads, cottages and other structures, were simply implemented without much discussion. Today, the norm is legally established in overarching plans and regional plans that state it should be very difficult to obtain permission to build anything in or near wild reindeer areas (e.g., Regional Plan for Rondane—Sølnkletten, 2013; Miljødirektoratet, 2023). Nevertheless, we see significant pressure on wild reindeer areas, and permissions are granted contrary to the norm, such as when the government permitted the construction of an alpine village in a wild reindeer area near the Hardanger Plateau (Bolstad, 2019).

In the context of hunting, Norway requires access to an approved tracking dog for hunting roe deer, moose and red deer, in order to humanely dispatch and recover wounded animals. In the USA, it is unethical and strictly forbidden to use dogs for any aspect of moose hunting. It is also interesting to see how our view of large predators has changed over time. The Norwegian Parliament passed a law in 1845 to eradicate eight predator species; later, in the 1970s, they were protected. In our time, Norwegian authorities have striven to keep predator populations at relatively stable, low levels. These official policies have conformed with prevailing attitudes and legislation at the time they were enacted. Heberlein (2012) emphasizes that norms must be simple and easy to explain. It is very difficult to establish new norms if they are not logical and easy to explain. New norms must also align with existing underlying values. Heberlein (2012) introduces the concept of the "grandchild test". If you cannot explain to your grandchild why we have a norm, you might as well give up, as the norm is not viable.

COGNITIVE, TECHNOLOGICAL AND STRUCTURAL CHANGES

Changing people's behavior can be challenging. The use of lead ammunition for hunting is harmful to both people and wildlife (Arnemo et al., 2022). Nevertheless, it is difficult to persuade hunters to stop using lead (e.g., Ellis & Miller, 2023). Heberlein (2012) discusses in detail how to change behavior through cognitive, technological and structural changes.

In the 1990s, the Norwegian Association of Hunters and Anglers (NJFF) and the authorities tried to make hunters understand that lead was harmful, hoping they would voluntarily stop using it. This was an attempt at a cognitive change, and as usual with cognitive change efforts, few changed their behavior. Then they tried to show that shotgun and rifle ammunition composed of alternative materials performed similarly to lead-based ammo (Gundersen et al., 2006). This is an example of an attempt at technological change. This will likely change the behavior of many hunters who use rifles and bullets. There are very good alternatives to lead bullets that do not contaminate. Most hunters fire limited ammunition so the difference in price is negligible. It is a bit different with shotgun cartridges. Many experienced that the first steel shot that became available in Norway had poor killing efficiency, probably because of the shorter effective range of lighter steel shot compared to lead (Gundersen et al., 2006). In addition, most small game hunters shoot many rounds, and good alternative game cartridges have been many times more expensive than regular lead cartridges. This makes behavior change difficult. The legal ban on lead shot in Norway between 2006 and 2015 was a structural change.

There was a problem with this structural change. The attitude of most hunters was that lead shot, in terms of animal welfare, killing efficiency and price, was the best option. When the Norwegian ban on smoking in public places was introduced, most people thought this was good. However, the majority of Norwegians have had no opinion on lead shotgun ammunition, while most hunters thought the ban on lead shot was wrong. Therefore, NJFF persuaded parliamentarians to allow lead shotgun ammunition again in 2015 after a nearly 10-year ban. This indicates that for structural changes to be sustainable, a majority of those who care must agree with the change. To implement the structural change, the EU had to adopt a ban on the use of lead shot in wetlands in 2023 to which non-EU member Norway has also complied. The term "wetlands" has been defined so broadly

(< 100 meters from flowing or standing water bodies) that lead shot is practically banned everywhere except for ptarmigan hunting in steep mountains and pigeon hunting on arable land far from water (Regjeringen, 2020).

We envision the mechanism of behavioral change as follows:

1. Someone wants to change people's behavior.
2. Campaign for change.
3. When the majority of the population shares the attitude that behavior should change, without having changed their behavior, restrictions and bans are imposed to prevent old behavior.
4. The bans make old behavior difficult to carry out.
5. Gradually, the new norm emerges.
6. Young people live according to the new norm, and the attitude is that what is common is right.
7. Those with old attitudes die. Attitude changes usually take a long time.

CLASSIFICATION OF WILDLIFE SPECIES

In Norway, wildlife species were previously defined as harmful or useful animals (hunting laws from 1845, 1863, 1899 and 1951). Today, The Norwegian Biodiversity Information Center, under the Ministry of Climate and Environment (KLD), classifies species according to a framework based on the rules of the International Union for Conservation of Nature (IUCN), which has defined the start of the Anthropocene as the year 1800 as the zero point. Species that were here in 1800, or that have arrived since without human assistance, are considered valuable species that we want to preserve. If any of them are at risk of extinction, they are listed on the Norwegian Red List[3]. Measures should ideally be implemented to remove them from the Red List. If species have been introduced by humans, they are placed on the alien species list. The worst are the competitive species introduced by humans, previously placed on the blacklist. If these alien species thrive and outcompete native species, they should be eradicated.

The idea that native species are good and introduced species are bad is a value choice that the Norwegian Parliament has endorsed. Nevertheless, it is not entirely consistent. The invasive king crab (*Paralithodes californiensis*) in the Varanger Fjord is managed sustainably east of the North Cape (Nordkapp) and has created a new industry. Cats, dogs, sheep, cows, goats, horses and pigs are all alien species brought by humans long ago and are accepted, even though introduced cats

3 https://artsdatabanken.no/Pages/135380/Norwegian_Red_List_for_Species

kill native songbirds (Nilsen et al., 2023) and introduced sheep graze on native grass important for native deer species. The wild boar (*Sus scrofa*) was eradicated in Scandinavia long before 1800, but the Swedes define it as native to Sweden although it had been reintroduced from sources in continental Europe. When this species migrates to Norway, the potential damage, especially to the pig industry, is one main argument for not considering it native to Norway, except if it comes from north of the Gulf of Bothnia from Finland; then it must be protected according to the regulations regarding natural immigration of species from endemic source populations. The small populations of large predators we permit are also related to their potential for economic damage, especially to free-ranging sheep. Our value perspectives on different scales influence wildlife policy.

HUNTING IN THE 21ST CENTURY

Here we will explore the reasons why many people still want to hunt when we can obtain our food in stores. Hunting is a common activity in Norway. In the 2023–2024 hunting season, 544,188 people, of whom 16.3% were women, were registered in the hunter register in Norway and had the opportunity to hunt (Statistisk sentralbyrå, 2024b, May 26). This is nearly 9.8% of the country's population. Of those who were over 16 years old and old enough to hunt, nearly 12% were in the hunter register. Of those, 134,100 people hunted, of which 9.4% were women. Of all men of eligible age, 20% are hunters. More people hunted cervids compared to small game. A total of 57,300 participated in moose hunting, 50,900 in red deer hunting, while 43,900 hunted ptarmigan (Statistisk sentralbyrå, 2024a, May 26). The typical ptarmigan hunter is a 50-year-old man who has hunted ptarmigan for over 20 years, has slightly more education than high school, and has an average income (Andersen et al., 2013). The number of cervid hunters has increased slightly over time, as has their average age, without the reason being known. It may be related to 1) difficulty for young people to join hunting teams and access a limited resource, 2) difficulty for parents of young children to commit to hunting teams if attendance is required until the quota is filled or 3) perhaps fewer young people are interested in big game hunting (Pedersen et al., 2021c). The hunt is highly valued by hunters, and Pedersen et al. (2020) found that hunters valued moose hunting far more than what they paid for it, and that the hunt saved society's health costs by keeping hunters in good shape. Nevertheless, it can be difficult to understand why people enjoy hunting in our time.

It is easy to understand why people had to hunt and fish before agriculture began. In Norway, there is little other food in the wild than game, fish, seafood and berries in the autumn. After agriculture started, it is also easy to understand why people hunted; a moose provided a large amount of meat compared to what a typical farm could produce. Snare-caught ptarmigans were a sought-after commodity. In our time, the cost of hunting for the average hunter is far higher than the income from selling the meat. Why then do hunters pay to hunt instead of leaving the wildlife to predators? In seven hunting grounds in Vingelen, Nord-Østerdal, which were leased for a total of 6 million NOK annually for a five-year period in 2022 (Løberg & Slåen, 2022), each harvested ptarmigan became rather expensive.

Manfredo (2008) investigated whether the joy of hunting and willingness to participate is something innate in our genes. His conclusion was that hunting is not a congenital need, but it is very easy for people to become fascinated by hunting and enjoy it if they are exposed to it. The importance of hunting for human development is disputed. Ardrey (1976) argued that we became humans because we hunted. Cooperation is crucial during hunting, and individuals who communicated best were the most efficient hunters. Those who were the best hunters had the most children, who themselves became good hunters and so on. Cooperation during hunting developed language, and our ancestors evolved into our species, *Homo sapiens*. Tanner (1981) argued that women and children gathering food were far more important than the men who hunted. Elgmork (1994) wrote that researchers often exaggerated the importance of hunting for the earliest human-like forms, but for our species, there is no doubt that hunting has always been important. Leakey (1996) stated that it is difficult to interpret what happened during human development; the evidence is quite old and is open to interpretation. He nonetheless dared to assert that it is likely our ancestors ate meat 4 million years ago, and certainly, they have eaten meat for at least 1.5 million years. At a symposium on meat-eating (Stanford & Bunn, 2001) it was concluded that our ancestors have consumed meat for several million years. There has been extensive debate about whether early humans primarily killed large prey themselves or chased predators away from the prey. Sayers and Lovejoy (2014) emphasized that it was not an either-or situation and that there was considerable variation in the diet depending on what was available in the habitat. Graeber and Wengrow (2021) also pointed to significant variation in food sources, but there is no doubt that hunting, trapping, fishing and a carnivorous diet have been extremely important for many groups for a very long time.

If providing meat for the family has been important for so long, it is reasonable that hunting has become something some people enjoy doing. People can enter a state of flow when they are engaged in something that truly captivates them. In a state of psychological flow, one can forget time and space and just continue with what one is doing. Punsvik and Storaas (1998) argued that humans most easily enter such a flow state when engaged in something that has had a fundamental survival function, such as hunting. Punsvik and Storaas (1998) further claimed that hunting is a process with three phases relative to the game animal: 1) stalking or chasing, 2) felling and 3) consumption.

People may have varying interests in these different phases. The Norwegian hare hunter is usually focused on phase 1. He may only want to find the hare and have a good chase with a dog, but often does not harvest the hare, saving it for the next chase. In the large hunts for British red grouse (*Lagopus scotica*), where beaters drive birds over the heads of wealthy individuals with double-barrel shotguns and loaders, then phase 2 (felling) is crucial. For many Norwegian moose hunters in the 1980s, procuring a lot of cheap meat (phase 3) was the driving force. Punsvik and Storaas (1998) argued that Nordic hunting is characterized by encompassing all phases. The game must be sought out and outwitted, harvested ethically, and the meat or fur must be used.

Betzig (2008) found that kings, who had the freedom to choose their activities, have historically been very keen on spending time and resources on hunting. She wondered why a ruler like the Mongol Kublai Khan could take time for annual three-month hunts when the hunt yielded so little and could be dangerous. Among others, Genghis Khan, two Roman emperors and three close descendants of Charlemagne lost their lives in hunting-related accidents. Betzig (2008) understood that hunting was useful before agriculture was invented but did not understand why kings wasted time and money on dangerous hunting instead of ruling the kingdom. Perhaps it was because the kings enjoyed it? Our conclusion is that hunting is an activity our ancestors have engaged in since before we evolved into humans. Humans tend to enjoy hunting when given the chance. For many hunters, hunting and training for it are important parts of life.

Majority rule in legislation is something hunting enthusiasts must note. Although 520,753 people were registered in the Norwegian hunter register, in 2020–2021 only 140,300 paid the hunter fee. In 2022, 1,076,977 people visited the Animal Park in Kristiansand. Many are interested in animals, but fewer are interested in using animals as hunting targets. But a full 20% of men over age 16 are in the hunter register. Likely, non-hunters may enjoy meals of tasty game harvested by their friends or relatives that hunt. It is perhaps not surprising that 74% in a Norwegian survey are positive toward hunting, and 86% trust that Norwegian hunting was carried out in a humane and responsible manner in 2017 (Hind & Svedal, 2017). Nevertheless, a large majority of non-hunting animal enthusiasts determine the future of hunting, and hunters should be aware that today's positive attitude can change if hunters do not maintain high ethical and moral standards.

HUNTING ETHICS VS. AGRICULTURAL ETHICS

Hunter organizations, along with public laws and regulations, set strict standards for hunting ethics. Hunters are expected to pursue wild animals that must be outsmarted, similar to the concept of fair play in football—hunting should be fair. The wildlife should have a genuine chance to outwit the hunter and escape. There are requirements for efficient killing, ensuring that death is as painless as possible. The idea is that a free human should outsmart and kill a free and wild animal that has every opportunity to evade the hunter in the open nature. Hunting is thus a game of chance where skill and luck can lead to success. The ethics are based on the notion that it is a joy-driven recreational activity where neither individual humans nor the survival of any species depends on the outcome. However, if the hunter succeeds, animals die earlier than they might otherwise.

In agriculture, the situation is different. Farmers and the population depend on food production. Therefore, it is crucial to secure the harvest in agriculture. The owner has a responsibility, defined by laws and regulations, to ensure that livestock are sufficiently well cared for. Farm animals have no chance of dying from old age; they will be slaughtered when it suits the owner's economic interests. This agricultural ethic is reflected in license hunts, such as the removal of wolverine pups from dens, wolf culling from helicopters and in some cases, winter culling in overpopulated moose herds. Here, the goal is to reduce the populations of certain species or efficiently harvest a meat resource. Mysterud et al. (2019a) documented how much more effective professional hunters, equipped with technical aids, were compared to regular hunters when the wild reindeer population in Nordfjella was to be eradicated. The ethics of these professionals that culled these reindeer was agricultural.

CONSIDERING ATTITUDES AND VALUES

Public wildlife managers can approach stakeholders with their attitudes and values in various ways. Decker and Siemer (2013) outline a progression from top-down management to a more equitable collaboration between authorities and interest groups:

1. **Expert authority approach**
   This is a top-down approach where wildlife managers make decisions and act unilaterally based on knowledge and priorities, often focused on the values of main constituents, such as consumptive users. There is no direct stakeholder input. This is seldom used today, except in emergency situations where actions must happen quickly (e.g., wildlife disease outbreaks).

2. **Passive-receptive approach**
   If stakeholders wish to provide input to wildlife managers, they can, but this is not actively solicited. This is advantageous for active stakeholder groups that are well organized but can be disadvantageous for less organized stakeholders with less influence or knowledge on how to influence management.

3. **Inquisitive approach**
   Managers actively solicit stakeholders for input on management decisions with regard to goals or methods. It can involve social science research to map important stakeholder preferences or opinions that can be used by managers to balance decisions regarding the pros and cons of different management scenarios.

4. **Intermediary approach**
   Managers work with different stakeholders to gauge their positions individually in order to weigh and balance concerns. Since stakeholders do not directly interact with each other, the manager is put in the position of finding a compromise between competing interests.

5. **Transactional approach**
   Stakeholders engage directly with one another to find objectives and actions that are mutually acceptable. Through this transaction, they collaborate to rank or weigh their stakes through deliberation to find consensus. This is often done by using a neutral, professional facilitator rather than a representative from the management agency.

6. **Co-managerial approach**
   Wildlife managers share management authority and responsibility with other government agencies, stakeholder organizations and local communities. This differs fundamentally from the other approaches since stakeholders and local people are directly empowered and responsible rather than just providing input regarding management decisions and actions.

All these models are used to some extent. A former wildlife manager in Iceland, Áki Armann Jönsson, told author Storaas that Icelanders went to Iceland because they did not wish to be subjects of a king. The tradition is that they are unwilling to follow a mandate just because it is a mandate; they want to understand why the mandate exists. If Áki made a regulation and got it approved by the department, the hunters would not necessarily follow it. But if he involved the hunters in making the regulation because they thought it was wise and good, they would zealously follow it—and ensure that everyone else did too. It is easier and requires less oversight if those closest to the mandate agree with it or understand why it is the way it is. In Alaska, indigenous communities play an important role in cooperative management planning, along with other stakeholders and federal and state agencies, in some rural areas and with respect to waterfowl and marine mammals. They do not, however, have direct management authority, but their role is essential in ensuring compliance.[4]

When predators began returning and large conflicts arose in Norway around the turn of the millennium, Reidar Andersen et al. (2003) led a collaborative project, "Predators and Society" (RoSa), funded by the Norwegian Environment Agency. Representatives of interest organizations, resource persons, and researchers met, talked under the leadership of a mediator, and agreed on a final report describing various aspects of the predator conflict. The report was based on research and provided a solid foundation for further management. The actors were, of course, still in disagreement, but they had become acquainted with each other and agreed on most facts. On Hardanger Plateau, there was significant disagreement between the Directorate for Nature Management (now the Environment Agency) and local landowners and managers regarding the size of the wild reindeer population. There was great strife and mistrust between the parties, and it turned out that local actors were right (Vaa, 2012b). The RoSa project was considered successful enough to start the project "Wild Reindeer and Society" (ViSa) on the same basis (Andersen & Hustad, 2004). Here, too, representatives, resource persons and representatives of interest organizations talked, signed a joint report and the conflict was mitigated.

When the military bombardment range in Hjerkinn was being restored, there was significant disagreement about how the Snøhetta area should be protected and used. A research project was initiated, resulting in the thematic booklet "Horisont Snøhetta" (Strand et al., 2013). The project mapped and emphasized the needs of both wildlife and people. While RoSa and ViSa were concluded projects, "Horisont Snøhetta" demonstrates how various actors and stakeholders can continue to collaborate in management as they acquire new knowledge.

REWILDING AND RESTORATION

Nature in Norway and the world is heavily influenced by humans. Many nature enthusiasts advocate for rewilding, or making nature wild again. There is not an

4 https://www.uaf.edu/caps/our-work/policy-perspectives-files/PB1%20Co-Management%20Policy%20Brief%2024%20Jan%202020.pdf

established Norwegian term for rewilding. The Norwegian Language Council provided several suggestions, and "*naturattføring*" (nature restoration) was chosen, implying that nature should be restored to something earlier, something more original. The first article on the Web of Science using the term "rewilding" appeared in 1999. By March 2023, the term had been used in 769 articles, with 450 of them in the 2020s, indicating a growing interest in this topic. Rewilding encompasses various activities such as recreating extinct species from ancient DNA, breeding back to forms resembling extinct species, introducing species that can play the ecological role of extinct species, reintroducing locally or regionally extinct species from other populations, releasing captive-bred wildlife, recreating lost habitats and even removing humans completely and leaving nature to itself (Carver et al., 2021). The term "rewilding" is fluid (Jorgensen, 2015). Carver et al. (2021) have developed 10 overarching principles for rewilding and show the gradual transition from urban to wilderness and in which cases rewilding is most relevant. Nevertheless, there is disagreement about what rewilding is. Many think that humans should withdraw from nature and that nature should flourish without human intervention (see Jorgensen, 2015; Corlett, 2016; Jones & Comfort, 2020; Schulte to Bühne et al., 2022). But nature can also be made wild again through active management (Ripple et al., 2022).

There is debate about whether wolves should be reintroduced in Scotland (Arts et al., 2016). In Japan, it is estimated that the human population will decrease by 24% by 2050, and that 20% of agricultural villages will be completely depopulated. As people concentrate in cities, conditions for wildlife will improve, and nature can become wild again (Tsunoda & Enari, 2020). In the book *Wolves in the Norwegian Cultural Landscape*, literary scholar and eco-philosopher Kvangraven (2021, p. 132) argues for rewilding in Norway as well. He writes, "Rewilding is not only based on biology and ecology, but also on ethics and aesthetics, and our need to experience awe in encounters with wild nature in intact wilderness areas. … Rewilding is based on an ecocentric view of nature, where nature is worthy of protection for its own sake, not just for human use and enjoyment." This eco-philosopher feels that nature in Norway will be much better for everyone if the wolf population was allowed to increase to a natural saturation point, such that they would keep prey populations healthy by taking out sick animals and preventing overly dense prey populations that overgraze food plants. Whether this is a realistic proposition or not can be discussed.

In Norway, the nature within the shooting range at Hjerkinn on Dovre was restored, referred to as "restoration," not "rewilding," in English. Nevertheless, the restoration fits within the English definition of rewilding. Significant emphasis was placed on collaboration between groups with different interests in the restored area (Breiby et al., 2022; Aasetre et al., 2022). Restoring the wolverine population on the Hardanger Plateau would likely be more challenging due to opposition from strong sheep grazing interests and farmer organizations (Punsvik, 2020). In Alaska, author Brainerd participated in the reintroduction of wood bison from Canada, an endangered species that had gone extinct roughly 200 years ago (Stephenson et al., 2001; Gardner et al., 2003). The discussion primarily revolved around whether it was acceptable to cull bison that threatened people and livelihoods, but most were generally satisfied with the restoration project (Doney et al., 2018; Doney et al., 2020).

Perspectives on rewilding largely depend on how the term is understood; it is currently a broad term where different people can support or oppose parts of its content. Views on the concept are also highly value-based. Do we place humans or all species at the center? At its core, it's a question of whether humans should be seen as part of and participants in nature or whether they should live in cities and leave nature to itself. In that case, it might be acceptable for people to move from rural areas and let them become wild without human intervention and management. Some aim to make nature more original by reintroducing species that were once in the area. The reintroduction of beavers (Auster et al., 2020) and white-tailed eagles (Sutton 2015) in the UK are examples. Reintroducing wolves in Scotland (Brown et al., 2011; Arts et al., 2016) would likely be very challenging. Wildlife reintroduction has been a common practice in many countries. A challenge with rewilding is the desire for nature to proceed on its own, without management. Without management, there would be raccoon dogs in Norway, which would be detrimental to species that have not evolved with it. However, the biggest challenge is developing clear Norwegian definitions, so we know what we are discussing when debating rewilding.

THE ROLE OF RESEARCHERS: THE HONEST BROKER

In this section, we will discuss whether we can trust researchers and managers, or if they manipulate facts to promote their own values. People often start studying nature because they are very interested in it and want to protect it. Can their fundamental values influence research questions, data collection, data interpretation, analyses and conclusions? Former Norwegian Minister of Fisheries Per Sandberg claimed several times in 2016 that researchers were biased, lacked integrity and were subjective when they produced results that contradicted the dreams of the salmon farming industry. The predator researcher has an especially challenging role, as they are easily suspected of wanting to protect the predators they study—or conversely of being in the pocket of the agricultural industry. It is difficult to present data that does not align with what people generally believe and want to believe. Both wolf supporters and, to a greater extent, wolf opponents accuse wolf researchers of being biased (Skogen et al., 2018). Norwegian wolf researcher Petter Wabakken was completely exonerated in 2017 by the National Research Ethics Committee after wolf opponents accused him of fraud. He had been meticulously careful to preserve all data and documentation and could account for all analyses and results (Magnussen, 2017).

It is not surprising that questions are raised about values and objectivity. Heeren et al. (2017) show that the opinions of professionals regarding whether hunting grizzly bears should be allowed to be established in the area outside Yellowstone National Park depend on their fundamental values and the environment they are in. Editor Nina Kristiansen (2015) at Forskning.no states, "Researchers are not neutral. They are active in societal debates. They want to change climate policy, health policy, and protect the environment. They argue for us to go in specific directions." Professor Anne Sverdrup-Thygeson (2015) responds, "I believe it is important to preserve the forest's species, including red-listed species in dead trees." And: "I also think it is important that we can use forest resources in a sensible way. And I hope it is possible to convey both." But it seems clear that Kristiansen thinks that researchers urge action and are not value-neutral.

Unfortunately, we have also seen examples of researchers committing fraud. In Sweden, long-deceased wildlife researcher Carl Gösta Notini reported that both capercaillie and black grouse tagged in the far north of Sweden were recaptured in the far south of the country. He was convinced that there were two types of grouse, stationary and migratory, and to prove this, he fabricated the recaptures. It is a huge problem if someone believes or wants something to be a certain way and then fabricates evidence to show they are right. Researchers are measured by how much they publish and how much they are cited. Undetected fraud can be career-advancing. Therefore, the consequences are serious when fraud is suspected, but it is often difficult to prove. Notini was heavily criticized and left the Swedish Association for Hunting and Wildlife Management (Westman, n.d.). But fraud is not always detected, and it is safest when multiple research groups arrive at roughly the same conclusion, as when the external research group appointed by the Storting (Stenøien et al., 2021) came to the same result as the wolf researchers (Liberg et al., 2012) that the South Scandinavian wolves are descended from the Finnish-Russian population.

Pielke (2012) discusses the role of researchers and presents four different roles researchers can choose to have (Table 3.4).

Table 3.4: Different roles researchers may choose (derived from Pielke, 2012, Table 6.1).

		View on Science	
		Linear Model	**Stakeholder Model**
View of a researcher's role in a democracy	Holds own values as correct	Pure Scientist	Advocate
	Accepts and respects other's views	Scientific arbiter	Honest broker of policy options

Some researchers do not care about utility but believe that utility will come eventually from their work. A purely basic researcher will conduct science for its own sake and is indifferent regarding its application or how it is viewed by others since they view themselves as completely objective. The scientific arbiter is equally unconcerned with utility, but when asked for advice they will try to answer as truthfully and accurately as possible. Other researchers try to find solutions to questions many are interested in. The advocate goes for one alternative that fits their own values and the values of the organization they work for. The honest broker of policy alternatives tries to provide multiple alternatives with different consequences and with decision-makers ultimately choosing the scenario they judge as most suitable when everything is taken into account.

Pielke (2012) also discusses a fifth type of researcher that does not quite fit into the predefined roles. This is the researcher who presents themselves as a pure basic researcher but, in reality, acts as an advocate. He calls this type a "stealth advocate," who claims to be unaffected by personal values but nonetheless promotes specific interests. This is problematic and undermines trust in science and researchers. Pielke advocates for scientists to choose the role of the honest broker. However, he writes that it is perfectly acceptable to choose other roles, as long as one is clear about their role and does not act as a stealth advocate.

In the USA, there are close ties between wildlife research and management. In Norway, there was a political desire to separate research and management to clarify the roles of managers and researchers and to allow more entities to compete for research assignments. In 1988, the research section of the Directorate for Wildlife and Freshwater Fish was placed in the new Norwegian Institute for Nature Research (NINA). Managers should base management decisions on political goals and the best possible knowledge. It is as important for managers as it is for scientists to be aware of the role they play, and the different roles researchers can choose to assume. For a management board, it can be useful to evaluate each alternative and expected outcome, to decide what action aligns best with values and goals. In many cases, based on personal values, it can be easy to narrow down the options for a management board. Norwegian public administration is based on the principles of Max Weber, which stipulate that the bureaucracy should be impartial, follow laws and regulations and ensure equal treatment. One principle promotes separation between the formal role and private agendas of bureaucrats (Rønning & Lesjø, 2015).

AUTHORS' REFLECTIONS

Proper wildlife and natural resource management depends on a solid understanding of people's attitudes, beliefs and values. Humans define their values, and these values and attitudes can vary over time and space. Previously, we defined pests to be eradicated and useful animals to be protected, while there were no rules for small non-game species of birds, hedgehogs (*Erinaceus europaeus*) or other species of wildlife of little concern to people. Now we classify them as native species on the Norwegian Red List if they face challenges or as invasive alien species if we prefer to exterminate them. With a different set of values, we could also imagine gold lists, lists of pleasant species that we would like to have more individuals or production of, and for which we could implement measures to promote. Peregrine falcons (*Falco peregrinus*) or capercaillie could be gold species. Many believe there are enough crows, foxes and wolves in Norway. They could thus be defined as gray list species, with the goal of ensuring they clearly survive in Norwegian nature, but at low densities. Humans are in a position to make value choices. The Norwegian Parliament represents the Norwegian people and makes value choices for us to which nature managers must loyally adhere. There is not always alignment between the values of the majority of people and those experiencing wildlife management challenges. In such situations, wildlife managers require knowledge about both wildlife and people.

The prevailing view in society develops and changes. Ole Dominicus Danielsen, great-grandfather to author Storaas, is quoted as saying, "I don't eat grass," when served salad. Today, climate challenges make his view hopelessly outdated. Since most perceive the right attitude as the one they themselves have at any given time, it takes a long time for attitudes to change. This is often very good. However, norms and behavior over time are changed by politics, legislation and enforcement. In Scandinavia, game meat is a tasty resource, but people hunt because they find hunting a good experience. Personally, those of us who hunt feel that the nature dwelling within us meets the nature surrounding us.

When people moved to cities, they brought with them attitudes and norms from rural areas. As people have lived in cities for several generations, the ties to farms and rural areas have weakened. Many see nature on TV and find meat wrapped in plastic in stores. Yet, in Norway, the old harvesting culture remains strong. Whaling and seal hunting are still legal. Several ministers have taken the hunter test and gone hunting. Newspapers and magazines with wide readerships write about hunting and fishing in positive terms. But strong forces work against it.

The European hunter organization FACE[5] is very concerned that hunting should not offend the general public. Author Storaas had the pleasure of lecturing at a hunting conference in the European Parliament in Strasbourg as early as 2003. Slides of dead animals were censored. At a large hunting exhibition, there were hunting clothes, silver jewelry shaped like animals, hats with feathers, and pictures of living animals in beautiful nature. Weapons and pictures of weapons and dead animals were banned. Afterward, in the evening, pheasant breast, wild boar ham and venison fillets were served on silver trays. It was acceptable to show the living animal in its environment and the meat on a plate. FACE did not want to offend the meat-eating public with how the living animal became food. Most people have distanced themselves from nature, but hunting still relies on public acceptance.

We have seen that the term "rewilding" encompasses many activities, and we should have more specific terms for each aspect. On one extreme is the idea that it is beneficial for people to move to cities. When rural areas are depopulated, they can be left to wild animals—without human intervention and management. Then nature can become wild again, and evolution can proceed without our interference. This thinking conflicts with how we have traditionally thought in Norway. For the authors, who are based in Nordic and North American cultures that view humans as users and parts of nature, it has been easy to translate extreme rewilding as "*forvilling*"—going astray. Restoring and rehabilitating nature through active management, on the other hand, seems to us to be beneficial for both people and wildlife. A tunnel from Haugastøl to Sysendalen would go under the migration routes of wild reindeer on the Hardanger Plateau. Restoring the migration route between the summer pastures for wild reindeer in the Snøhetta area and the winter pastures in Knutshø and Rondane would be fantastic.

How the future unfolds depends on political development and the evolution of values, norms and regulations. It has been a reputational challenge that hunters want to use lead shot because it kills best and is cheap, even though lead contaminates game meat and the environment[6]. Big game hunters have little reason to

5 https://www.face.eu/

6 Lead from ammunition harmful to public health | Tidsskrift for Den norske legeforening

use lead when good alternatives exist. There could also be a reputational challenge if hunters wanted to eradicate all wolves in the country. Norwegian hunters should note that fur farming in Norway is being phased out following a decision in the Parliament. Admittedly, there are 1,000 times more active hunters than there are fur farmers. But to continue their activities, hunters need to be aware of trends and adapt to societal changes. Humans determine how nature and the use of nature develop. Knowledge concerning wildlife and ecology is useless if people do not care. Politics ultimately decides the future of animals, humans and the environment.

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Scandinavian University Press.
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4. Legislation

Legislation has evolved over time based on needs and sets the framework for how wildlife can be managed. In this chapter, we will examine Norwegian wildlife legislation against a historical and international background. Hunting rights and, to some extent, hunting methods are generally determined nationally, while conservation is often regulated by international conventions. We will first discuss three areas of law: 1) who has the right to use wildlife, 2) conservation and protection of wildlife and their habitats and 3) respect for animal welfare. We will then review a number of international conventions that the Norwegian Parliament has ratified and to which our laws are adapted. We will cover the EU's nature conservation regulations. Although Norway is not obligated to follow these as part of the European Economic Area (EEA) agreement, it is important for many of our partner countries. We will then review the development of Norwegian wildlife legislation up to the current Wildlife Act (1981) and the Nature Diversity Act (2009). We will also highlight other laws relevant to wildlife management. The Wildlife Act is specified in regulations that are constantly changing, so we will only mention them briefly. Finally, we will present some wildlife-related court cases. We hope the chapter provides a good background for understanding Norwegian wildlife management rules, with some thoughts on how they can be further developed.

THE RIGHT TO USE WILDLIFE

We humans have lived, like our ancestral species, through hunting, trapping, fishing and gathering. Graeber and Wengrow (2021) have shown that pre-agricultural people organized themselves in many different ways based on resource availability, political views and power relationships. There is therefore no reason to believe that there is an original right way to distribute hunting rights.

For many other animal species, it is common to defend limited resources if possible, and animals that control a resource often win over intruders. For people, it was probably less profitable to defend areas far north where large reindeer herds vary their migration patterns and usage areas. If the reindeer came to where the people were, there was enough for everyone. If the reindeer were elsewhere, they could just as well move to where they were. In more fertile hunting areas further south in America, Kay (2007) found that Native American tribes defended their hunting areas against other tribes.

In Europe, hunting rights have historically often oscillated between landowners and nobility, who were often also landowners. Johan Georg I (1585–1656) and his son Johan Georg II (1613–1680), both Electors of Saxony, organized driven hunts where the drives ended in pools where the animals had to swim while the Elector and guests shot them. Johan Georg I and his son, respectively, killed 116,443 and 109,318 mammals, primarily through such hunts (Høgh & Perto, 2011).

Emigrants from feudal Europe to America created legislation to ensure hunting rights in the colonies that later became states. In France, the nobility enjoyed exclusive hunting rights until the revolution in 1789. The revolution declared that private areas and forests should be open for hunting for anyone, which partly applies to this day, according to Piketty (2021). In Sweden, the king had hunting rights, but around the time of the French Revolution in 1789, King Gustav III returned the hunting rights to landowners (Tillhagen, 1987; Danell et al., 2016). In Sweden, this led to very intense hunting pressure, and regulations had to be introduced.

WHO OWNS WILDLIFE?

Globally, there are examples where wildlife is either completely protected (Kenya and India), landowners hold hunting rights on their property (Norway) or wildlife on fenced land (South Africa), or the public owns wildlife (Switzerland, USA). There is a significant difference in principle between a legal framework that allowed Archduke Franz Ferdinand to kill 272,511 game before he was assassinated in Sarajevo in 1914 (Høgh & Perto, 2011) and free Norwegian wild reindeer hunting, where the landless hunter Jo Gjende could go to the mountains and hunt as many wild reindeer as he could manage.

In Europe, landowners do not own wildlife (Putman, 2011). It is either owned by everyone (*res communis*) or no one (*res nullius*). The difference is that when owned by everyone, the state can choose to sell hunting licenses or delegate management to wildlife management organizations or bodies. When wildlife is owned by no one, the landowner typically plays a larger role.

Table 4.1: Ownership of wildlife in various European countries (after Putman, 2011).

Ownership	Countries
Res communis (the public owns the wildlife)	Croatia, Finland, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Slovenia, Switzerland and Hungary
Res nullius (no one owns the wildlife)	Austria, Belgium, Denmark, England and Wales, Estonia, Latvia, Norway, Scotland, Spain, Sweden, Czech Republic and Germany

In Norway and Sweden, where no one owns the wildlife, landowner rights are strong. The landowner has hunting rights, except when hunting rights were separated from landowner rights before the Hunting Act of 1899, as laws are not retroactive. The landowner can be either an individual or a private or public organization or entity. A landowner can agree to lease hunting rights separately for up to ten years through written agreement, according to the law Wildlife Act § 28.

Legislation also regulates the right of trespass. In Norway, the public can trespass on private or public property with few restrictions. In England, the landowner has the right to decide who can trespass on their land, but people have rights of way along old paths and roads. In the USA, landowners can prohibit others from trespassing. It is of little use for the public to own wildlife but have nowhere to hunt. The conclusion is that whether hunting should be allowed and who should be allowed to hunt are political questions that various stakeholders may have differing opinions on.

SECURING THE RESOURCE

Humans have a long history of overexploiting populations to the point where it is no longer profitable—the so-called "Tragedy of The Commons" (see Hardin, 1968). When an individual is extremely valuable, the risk of extinction is high. In the 1880s, whalers calculated that if they managed to catch a North Atlantic right whale (*Eubalaena glacialis)* or bowhead whale (*Balaena mysticetus*), the entire expedition was paid for, and additional whales were pure profit (Cherfas, 1989). The fact that these species survived at all was due to the vastness of the ocean, with ice in the north, and the hunters not being able to find all the whales despite considerable effort. Today, international agreements and conventions aim to ensure the survival and potentially sustainable use of wildlife that crosses national borders.

Within national borders, there are many examples of overexploitation and extinction. For instance, valuable beavers were eradicated in Sweden and the United Kingdom (Ellegren et al., 1993; Manning et al., 2014). Legislators in various countries have employed several measures against overexploitation. One approach is to grant exclusive rights to the king, nobility, state, local community, trapper or hunter to use the resource in a specific area. South Africa has adopted the principle that landowners can earn money from wildlife, which has incentivized them to protect it. This has worked for some species, but public regulations are needed to protect others (Cousins et al., 2010). Regulations can include total protection, seasonal protection, quotas, or restrictions on legal hunting and trapping methods. With limited knowledge of population size and production in wildlife populations, it may be wise to make wildlife harvesting difficult through hunting seasons and methods. If population size and dynamics are well known, harvesting can be more effectively managed through quotas.

Modern legislators have recognized that it is not enough to protect species—habitats must also be preserved. In Norway, the goal is for landowners themselves to manage huntable species such as roe deer, red deer and moose in accordance with municipal objectives and wild reindeer according to national goals. Landowners can manage small game hunting according to their own wishes within the framework set by laws and regulations. It is the responsibility of the authorities to ensure laws and regulations protect all native species and their habitats.

RESPECT FOR ANIMAL WELFARE

For a long time, legislation did not address how people should behave toward domestic or wild animals. Even in the 1800s, coastal inhabitants in Norway used nets to trap whales in bays and shot them with poisoned iron arrows, a process that could take up to 17 days (Ringstad, 2011). The primary goal was to kill the animal to use its skin, meat, oil, or whatever resource they needed. People saw the suffering of animals and founded animal welfare societies in England (1824), Norway (1859) and the USA (1866). However, rules for improving animal welfare were first enacted in the Norwegian Hunting Act of 1951 and furthered in the current Animal Welfare Act (2009). The Wildlife Act and adherent regulations also include rules that aim to prevent unnecessary suffering.

What is considered unnecessary suffering varies between cultures. While fur trappers in America use steel leghold traps and red fox trappers in Northern Sweden use foot snares, these practices are prohibited in Norway. The ancient hunting method known as "coursing" involves a pack of dogs chasing deer, foxes or wild boar until the prey escapes or is killed by the dogs. Sometimes hunters kill the prey with a knife. This method remains legal in about 20 countries, including France, Ireland and the USA. In Norway, killing with dogs or a knife is prohibited, but Norwegian law allows commercial killing of whales (not categorized as wildlife) by harpoon cannons followed by rifle shots. Norwegian regulations require rifles with sufficient impact energy or shotguns for various game species. In the USA, there are specific hunting seasons for bow and arrow, muzzleloader, rifles and handguns.

The current Norwegian Wildlife Act requires that hunting be conducted humanely (§ 19). The Regulations for the Practice of Hunting, Culling and Trapping (Jaktutøvingsforskrifta, 2002) detail how this should be carried out in practice. In Norway, there are dedicated animal welfare organizations. NORECOPA[1] (Norway's

1 https://norecopa.no/about/consensus

National Consensus Platform) seeks alternatives to using animals in research. The Norwegian Food Safety Authority (Mattilsynet) oversees animal welfare, and the government has established a dedicated animal police to investigate and prosecute those who violate laws and regulations regarding animal treatment.

INTERNATIONAL CONVENTIONS

In the 1970s, it became clear that international cooperation was necessary to protect nature. This led to international agreements that have become part of the legislation in ratifying countries. The EU has adopted the Habitat Directive[2] and the Birds Directive[3] based on conventions pertaining to the environment and biological diversity and serve as management tools within the EU. Environmental legislation in Sweden, Denmark and Finland must align with these directives. Here are some key conventions:

The Convention on Wetlands

The Convention on Wetlands[4], or Ramsar Convention, was adopted in Ramsar, Iran, in 1971. It is the oldest international nature conservation agreement in Europe and has been signed by 167 countries to protect wetlands down to a depth of 6 meters. In America, the USA and Canada signed the Migratory Bird Treaty Act (MBTA) in 1918 which also provided for the conservation of waterbirds and their habitats in North America.

The Ramsar Convention provides guidelines for national plans and measures, as well as cooperation between countries for the conservation and sustainable use of wetlands and associated resources. Norway ratified the convention in 1975, becoming one of the first countries to do so. Nearly 20,000 km^2 of wetlands distributed across over 2,100 areas are listed under the Ramsar Convention as wetlands of international importance. The convention has a secretariat in Switzerland, and member countries meet every three years to discuss progress and plan the way forward.

Convention on the Conservation of European Wildlife and Natural Habitats

The Convention on the Conservation of European Wildlife and Natural Habitats[5] was adopted in Bern, Switzerland, in 1979 and ratified by Norway in 1986. It is

2 https://environment.ec.europa.eu/topics/nature-and-biodiversity/habitats-directive_en
3 https://environment.ec.europa.eu/topics/nature-and-biodiversity/birds-directive_en
4 https://www.ramsar.org/
5 https://www.coe.int/en/web/bern-convention

a binding agreement or treaty between 45 European countries, the EU and five African states, focusing on the conservation of wild plants and animals and their natural habitats. Expert groups develop action plans and provide advice on monitoring (Emerald Network: Bern Convention 1989) and policymaking. Countries must give special attention to the conservation of threatened and vulnerable species, with four lists detailing the species covered by the convention:

- **List I:** Lists approximately 700 plant species, including vascular plants, mosses and algae, that member countries must fully protect. There are 25 of these species in Norway.
- **List II:** Includes about 700 animal species, such as mammals, birds, reptiles, amphibians, fish, insects, mollusks, echinoderms, corals and sponges, which are protected against capture, hunting and egg collection. In Norway, there are 145 bird species, including 30 mammal, one reptile, one amphibian, four dragonfly, four beetle and three butterfly species.
- **List III:** Enumerates most European animal species not included in List II, including Atlantic salmon (*Salmo salar*). Species on List III can only be used in ways that do not threaten their populations.
- **List IV:** Prohibits certain hunting and trapping methods, such as using glue to catch small birds, foothold traps, toxic bait and snares for mammals.

Our Norwegian Wildlife Act from 1981 and the subsequent Nature Diversity Act[6] (2009) are adapted to the Bern Convention., The treaty obliges countries to protect both species and habitats. It places particular emphasis on the conservation of threatened and vulnerable species and species that migrate across large areas and borders, such as migratory birds and large predators. Norwegian regulations for limitations on the number of rounds allowed for shotguns and rifles are not based on this convention, however. Several opponents of predators claim, without support from the government, the parliamentary majority, or the judiciary, that the convention does not prevent the eradication of wolves and bears in Norway.

The Council of Europe (CoE) has the secretariat, and member countries have annual meetings. Members have expressed a desire to use the Bern Convention as a regional tool to implement goals adopted in the Convention on Biological Diversity (CBD; see below). Author Brainerd has developed three charters on sustainable use and biodiversity for the standing committee (SC) of the Bern Convention through the CoE secretariat on hunting (Brainerd, 2007), recreational fishing (Brainerd 2010) and fungi-gathering (Brainerd et al., 2013).

6 https://www.regjeringen.no/en/dokumenter/nature-diversity-act/id570549

Convention on Migratory Species

The Convention on Migratory Species (CMS)[7] was adopted in 1979 in Bonn, Germany. Also known as the Bonn Convention, CMS is a global agreement among 119 countries for the conservation of migratory wild species that regularly traverse national borders. The convention creates lists of migratory species that require special protection and management. On the list of the most threatened animals are Norway's white-tailed eagle (*Haliaeetus albicilla*) and sperm whale (*Physeter macrocephalus*). The Bonn Convention promotes action plans for threatened species and works to establish migratory corridors for birds that breed in the north and winter in the south. Norway has taken overarching responsibility for the lesser white-fronted goose (*Anser erythropus*). The secretariat is located with other United Nations (UN) secretariats in Bonn.

Agreement on the Conservation of African-Eurasian Migratory Waterbirds

Within the framework of the Bonn Convention, this agreement, also known as the African-Eurasian Waterbird Agreement (AEWA)[8], has been specifically developed for the conservation of migratory waterbirds and their habitats in Africa, Europe, the Middle East, Greenland and the northern islands of Canada. Through it, management plans have been developed for migratory waterfowl species including the graylag goose (*Anser anser*; Powolny et al., 2018).

Convention on International Trade in Endangered Species

The Convention on International Trade in Endangered Species (CITES)[9], also known as the Washington Convention, was established in Washington, D.C., in 1973. It is a global agreement on the trade of wild animals and plants. All but six countries in the world have signed the convention. Norway has its own CITES regulation, which aims "to limit the harmful effects international trade may have on the continued existence of animal and plant species that are or may become threatened with extinction" (CITES Regulation 2018).

Over 38,700 species, nearly 5,950 animal species and 32,800 plant species, are protected by CITES against overexploitation through international trade. They are listed on three different lists. List I includes the most threatened species, and

7 https://www.cms.int/
8 https://www.unep-aewa.org/
9 https://cites.org/eng

international trade of these species is prohibited. List II includes species that may become threatened if trade is not regulated. Species that resemble more threatened species can also be on this list, requiring export permits. For his master's thesis in Montana, author Brainerd studied the American bobcat (*Lynx rufus*) with funding provided to ensure that trade of the fur of this common species was not regulated under CITES, since it somewhat resembles threatened and endangered spotted cat species. List III includes species that participant countries need international help to prevent overexploitation.

As situations change, species can be moved between List I and II, and species can be listed differently in various countries. For example, wolves are on List I in Bhutan, India, Nepal and Pakistan but are on List II in all other countries. Countries can make reservations to not follow the lists for certain species. For instance, the minke whale (*Balaenoptera acutorostrata*) is fully protected on List I. Norway has reserved its position and allows the annual harvest of several hundred to over 1,000 minke whales. The challenge for the Norwegian whaling industry is that the meat cannot be exported and must be consumed in Norway. Thus, CITES regulations have resulted in reduced harvest of minke whales.

South Africans believe they could finance the conservation of elephants and rhinos through sustainable harvesting and the sale of ivory and rhino horn (see Di Minin et al., 2022), and they are attempting to move elephants and rhinos in South Africa from List I to List II, but have not succeeded so far.

Convention on Biological Diversity

Also known as the Rio Convention, the Convention on Biological Diversity (CBD)[10] was established in Rio de Janeiro, Brazil, in 1993. It is a global agreement between 196 parties (including 195 countries and the EU) focused on the conservation and sustainable use of biological diversity. It has been ratified by 30 countries, with the United States being the only United Nations (UN) member state that is a party but has not ratified the treaty. The convention builds on the work of the World Commission on Environment and Development, known in Norway as the Brundtland Commission, led by former prime minister Gro Harlem Brundtland. The agreement also addresses the fair distribution of benefits from the use of genetic resources. The convention aims to achieve its goals both globally and nationally. The Malawi Principles (1998) and Addis Ababa Principles (2004) are based on this convention. In 2022, under this agreement, a nature pact was adopted with the goal that member countries practice 100% sustainable nature

10 https://www.cbd.int/

management and that 30% of land and sea areas be protected by 2030 (Ministry of Climate and Environment, 2022b).

The following is a short presentation of these principles and the European Charter on Hunting and Biodiversity that was derived from these under the auspices of the Bern Convention.

Malawi Principles (1998)

The Malawi Principles consist of 12 principles that should underpin ecosystem-based management and are foundational to Norwegian nature management. The principles emphasize the importance of local participation in conservation processes. The Malawi Principles assert that management goals are something society can choose, that management should occur at the lowest possible level and that the ecosystem must be managed within an economic context.

Addis Ababa Principles (2004)

The Addis Ababa Principles provide guidelines for the sustainable use of natural resources through 14 practical principles. These principles stress the importance of robust legislation and institutions, the use of science and local knowledge, transparent monitoring and consideration of how local economies are affected.

European Charter on Hunting and Biodiversity

Developed on behalf of the Bern Convention and the Council of Europe (CoE), the European Charter on Hunting and Biodiversity is based on both the Malawi and Addis Ababa Principles of the CBD. This charter provides guidelines on how hunting and biodiversity can be managed sustainably, ensuring that hunting practices contribute to conservation goals. Author Brainerd led a Working Group (WG) of relevant experts and representatives from non-governmental organizations (NGOs) and governments of EU Member States to formulate the charter (Brainerd, 2007).

HABITAT DIRECTIVE, BIRDS DIRECTIVE, NATURA 2000 (EU)

Based on international conventions, the EU has established its own, stricter regulatory framework. The Habitat Directive ensures the protection of a range of rare, threatened or endemic animal and plant species. The directive lists around 1,000 species and 200 habitat types for varying levels of protection. The Birds Directive aims to protect all of the roughly 500 bird species found in the EU. It includes five lists specifying the measures that must be taken for different species. The directive also addresses sustainable hunting and the culling of birds that cause damage. Natura 2000 is a network of protected areas covering 18% of land and 6% of marine areas in the EU, designed to ensure the survival of valuable and threatened habitat types and species.

Finland and Sweden, as EU members, are bound by the Habitat Directive, but since predator protection is not part of the EEA agreement, Norway is only bound by the Bern Convention and not these directives. Under the Habitat Directive, wolves must have a favorable conservation status in member countries. If a wolf migrates every five years, a Swedish wolf population of at least 300 individuals would be sufficient. The EU can override Swedish decisions. The Norwegian Supreme Court has ruled, based on Norwegian law and the Bern Convention, that the Norwegian wolf population is part of the Swedish population, and therefore Norway does not need to maintain a viable population within its borders (Norges Høyesterett, 2021).

HISTORY OF NORWEGIAN WILDLIFE LEGISLATION

Early history

Few Sami lived off hunting and fishing in the north and inland further south (NOU 2007:14), but we know more about the laws of the Germanic Norwegian population. Officials known as law speakers knew the legal texts, but at regional assemblies, there were often power struggles between farmers, chieftains and kings, and the opinions of commoners and slaves mattered little. The saga says that King Eirik Bloodaxe overrode the Gulating assembly and denied Egil Skallagrimsson his inheritance rights according to the law (Heggstad, 1994), which led to the king losing the support of the farmers, which contributed to him being exiled (Titlestad, 2011). Later, Egil won another case at the Althing in Iceland, not necessarily because he was right, but because he had the most supporters. Egil nonetheless followed the rules and obtained a decision that was respected, taken in the manner such decisions should be taken.

The Gulating Law contained rules about property rights to salmon fishing in rivers, stranded or captured whales, falcons, animal traps and hunting devices. The goal was to resolve conflicts over the right to use resources. Bernssen (2020, p. 524) writes that the greatest authority on medieval law, jurist and legal historian Knut Robberstad, translated the Gulating Law as follows in 1937: "With weapons, everyone shall have the right to hunt animals, regardless of who owns the outlying land." Bernssen writes that those other major legal historical authorities also believed that medieval laws contained a principle of free hunting. Bernssen (2020, pp. 522–523) also states: "Regulation of hunting is found in all legal and law books in Norwegian legal history." And that "The traditional view of medieval law is that it contained a fundamental principle of common hunting rights with weapons. Hunting with dogs and setting traps, on the other hand, was the landowner's exclusive right."

Rules from the Frostating and Gulating Laws were largely continued in Magnus Lagabøte's national law from 1276 (Taranger, 1962). This law also included a prohibition aimed at protecting wildlife: a ban on hunting moose on skis (Taranger, 1962). Skiers with spears or bows and arrows must have been particularly effective in deep snow or on crusted snow, which supported the hunter but not the moose. The Norse laws were translated into Danish and with minor changes continued first in Christian IV's Norwegian Law from 1604, later in the law of Christian V from 1687. Bernssen (2020, p. 525) writes: "Regardless of conclusions about medieval law, free hunting through Norwegian law from 1604 and 1687 stood as a fundamental principle until the law change in 1899."

In 1730, the Danish government in Copenhagen introduced regulations for big game hunting in Norway with seasons, protections, bounties and severe fines for violations (Søilen, 1995). The resistance was strong, and the regulations were overturned as early as 1744. The general pattern moving forward was:

1. The landowner had the right to trapping sites and hunting with dogs for useful game on their own land.
2. The landowner could, within a defined hunting season, kill a certain number, often one big game animal, on their own land. The animal could be pursued onto another's land until it was killed. The harvest was regulated through the hunting season, which was often very short.
3. Authorities introduced various protections during breeding seasons for some species.
4. In certain periods, moose were completely protected (1733–1736, 1760, 1818–1823) (Søilen, 1995). Landowners, like those in Østerdalen in 1776, imposed their own strict regulations on moose and reindeer hunting with severe penalties (Andersen et al., 2009).

Skavhaug (2005) stated that before 1899, all Norwegians had the right to:

1. Hunt wolves and bears everywhere, with or without dogs.
2. Hunt without dogs in outlying areas for all wildlife except moose, red deer and beaver.
3. Hunt without dogs in "heimemarka"[11] for predators and useful game species that were not protected at any time of the year.

11 "Heimemarka" includes fenced and unfenced pastures where everyone can hunt.

4. Hunt on public commons, with and without dogs, for all wildlife except moose, red deer and beaver.
5. Trap predators on public commons.

In Norway, the population increased throughout the 1800s, resources became scarce and heavily exploited. Conservator Halvor Heyerdahl Rasch believed this led to overexploitation and poor utilization of wildlife resources. Earlier, as early as 1730, bounties were established for wolves, and in 1733 for bears (Bernssen, 2020). But Rasch felt more legislation was needed. Based on his work, the "Act on the Extermination of Predators and Protection of Other Wildlife" was introduced in 1845 and slightly amended in 1863. The law divided animals into pests and useful animals. The principles were:

1. Extermination of pests.
2. Protection, protection periods and hunting restrictions on useful game.
3. Other wildlife was considered uninteresting.

The eight species then considered to be vermin—wolves, bears, wolverines, lynxes, golden eagles, white-tailed eagles, goshawks and eagle owls—were to be eradicated. The red fox was thoroughly assessed in the preparatory work for the law. They concluded that despite red fox depredations on poultry and lambs, it also took harmful small rodents, and its fur was so valuable that it was considered a useful animal (Richardsen, 2012). Reactions to violations of wildlife legislation were grounded in the "Act Concerning Crimes" of 1842, Chapter 22, § 11, with a new print in 1849 with footnotes referencing the Hunting Act of 1845:

> Anyone who illegally kills, captures, or injures wildlife on another person's land outside fenced game reserves shall be fined, if it is large game, which includes moose, red deer, or reindeer, up to twenty specie dollars, and if it is other wildlife, up to ten specie dollars. If someone illegally hunts on another's land, they shall be fined up to five specie dollars, even if they have neither killed, captured, nor injured any wildlife there.

In the law from 1863, Rasch wanted to include a ban on certain cruel animal torture trapping methods, but the Parliament deemed it unnecessary (Søilen, 1995).

The hunting pressure on useful game was still perceived as too intense. Barth (1881b, p. 435) wrote: "To shoot capercaillie over a dog—this is a hunter's finest hunt—is soon a thing of the past in this country." He attributed this to deforestation and the fact that anyone could shoot capercaillie on the lek during the spring mating season lek and on treetops in winter. Groups of hunters would travel from area to area, harvesting most of the birds, he noted. Meanwhile, city hunters, organized in NJFF since 1871, and many landowners disliked that anyone could hunt without dogs, thereby disturbing their hunts. With the current regulations, it was difficult or impossible to control hunting pressure and harvests. To improve the situation, either a public wildlife management system had to be established or hunting rights had to be transferred to private individuals. Wealthy sports hunters who led NJFF and landowners argued that if landowners had full hunting rights, they would take care of the wildlife. Søilen (1995) writes extensively and in detail about the long struggle to extend landowner hunting rights. He tells an exciting story, and it was difficult to predict what the Parliament would decide.

HUNTING ACT OF 1899

The Norwegian Constitution was signed by 112 upper-class representatives in 1814. In the 1897 parliamentary election, only wealthy men, 12% of the population, had the right to vote (Borgersrud, 2000). In the 1900 election, all men over 25 years old (who were not criminals) would be able to vote. No one had any illusions that this Parliament would give hunting rights from the people to the landowners; if landowners were to get all hunting rights, there was a rush. The Agriculture Committee now translated Gulating Law § 95 as: "With weapons, everyone who owns a forest shall hunt animals wherever he can […]". With such a change in wording, the principle of free hunting for everyone was turned into free hunting for landowners (Bernssen, 2020, p. 24). After long discussions, a slim parliamentary majority gave landowners hunting rights to useful game in the Hunting Act of 1899. It was likely also contributing that the Parliament felt they had to choose between giving landowners hunting rights or paying for a public wildlife management system. They chose the cheapest option, assuming that landowners would take care of the wildlife.

The main principle was that landowners had all hunting rights to useful game, while everyone could still hunt wolves and bears, but had to notify the landowner. All Norwegians were given hunting rights in state commons. The start of the ptarmigan hunting season was postponed from August 15 to September 15 as a nod to city sports hunters. Many viewed the law as theft of the right to free small game and reindeer hunting from ordinary people (Søilen, 1995), a debate that continued into the 1950s. Attorney Jakob E. Vik (1930) briefly asserted that landowners had always had all hunting rights, while attorney Sverre Østlie (undated), in a book likely published in 1954, reviewed all hunting legislation and convincingly argued that a right was taken from the community and given free of charge to landowners.

HUNTING ACT OF 1951

In 1932, the Hunting Act of 1899 was amended such that landowners were given exclusive rights to hunt predators and birds of prey. Hunting capercaillie and black grouse during their lek was banned (Skavhaug, 2005). Dissatisfaction with the Hunting Act of 1899 led to new legislative efforts starting in 1937, but the work was postponed due to World War II. When arguments were made to return hunting rights to the people in the lead-up to the new Hunting Act of 1951, lawyers claimed that landowners would need compensation (Kjos-Hanssen, 1983; Bernssen, 2020).

The Hunting Act of 1951 introduced several significant innovations:

1. Wildlife management would have its own administrative apparatus.
2. Fees were imposed on trapping and hunting to help cover the costs of wildlife management.
3. Governmental wildlife committees in municipalities. The municipal council appointed landowners and hunters interested in and knowledgeable about wildlife and wildlife management as members. They discussed how many big game animals could be harvested and distributed permits to hunting rights holders based on the size of the area they managed. Landowners could cooperate to secure sufficient area for at least one animal. Municipally set minimum area requirements were a prerequisite for the upcoming increase in big game populations because the committees were cautious and set quotas low enough for populations to grow.
4. A new principle was that wildlife should not suffer unnecessarily.
5. Authorization to introduce shooting tests and caliber and bullet requirements for big game hunting.
6. The ban on leghold traps, originally instituted in 1932, was continued.
7. It remained illegal to use multiple cartridge rifles for wild reindeer hunting. Only single-shot rifles were permitted due to the belief that this would help to reduce wounding loss.

Landowner hunting and trapping rights were emphasized. However, it was also stressed that landowners should consider the public's need for hunting and trapping, although it was difficult to find good provisions to ensure this. Additionally, considerable emphasis was still placed on predator control. Hunting wolves, wolverines and lynxes was free for all Norwegian citizens, and wildlife authorities could formulate specific regulations. Municipal wildlife committees could grant individuals the right to hunt birds of prey and predators regardless of land ownership.

Some rules from that time might seem curious today:

§ 33. Calves of moose, red deer, wild reindeer, fallow deer (*Dama dama*) and roe deer must not be harvested without specific permission from the wildlife authority. It was considered good ethics to kill the cow rather than the calf, as it was seen as poor ethics to kill the "poor little calf."

§ 37. Swans (*Mutus mutus*), eider ducks (*Somateria mollissima*), king eider ducks (*Somateria spectabili*), gannets (*Morus bassanus*), fulmars (*Fulmarus glacialis*) and little gulls (*Hydrocoloeus minutus*), as well as all owls except eagle owls and snowy owls (*Bubo scandiacus*), are protected all year round. A few bird species were completely protected, some birds had specific hunting seasons, and all other bird species were huntable from August 21 to the end of February.

§ 49. The wildlife authority may permit the use of phosphorus compounds to eradicate crow birds. Upon recommendation from the municipal council, the wildlife authority may, under specified conditions, grant permission for the use of poison to capture predators in the municipality. Using poison to kill animals is considered highly unethical and unlawful today. In 2002, a person who put out poison bait for wolves was sentenced to 120 days in prison. Under the 1951 Hunting Act, however, the use of poison was entirely permissible.

§ 53. The wildlife authority may establish bounties for the killing or capture of mammals and birds deemed particularly harmful. The law clearly indicated that some wildlife species were considered harmful.

The Hunting Act of 1951 was very clearly a hunting law. The purpose of the law was not explicitly defined, but it was clear that wildlife could be divided into useful animals, harmful animals and animals of little significance. Useful animals were to be protected, harmful animals were to be combated, neutral animals had breeding season protections and a few species were fully protected because they were rare or had a useful function. For example, small owls were considered to be useful for controlling mice.

WILDLIFE ACT OF 1981

In the 1960s and 1970s, Norwegian society and attitudes toward nature changed. People moved to cities and became much wealthier. The book *Rovfuglene og viltpleien* ("Raptors and wildlife management"; Hagen, 1952) showed that birds of prey were magnificent birds and not as harmful to small game as people thought. The environmental movement and the public interest in nature conservation grew.

The Wildlife Act[12] of 1981 marked a shift in Norwegian wildlife legislation in the wake of the 1979 Bern Convention, reflecting changes in societal attitudes toward nature and wildlife conservation:

1. **§ 1. (Purpose):** This legislation is not just a hunting law but a wildlife law. It introduced a purpose clause: "Wildlife and wildlife habitats shall be managed to preserve the productivity and species diversity of nature. Within this framework, wildlife production may be harvested for the benefit of agriculture and outdoor recreation". Not only wildlife but also their habitats must be protected. Previously, habitats could be destroyed even if the species were protected. The productivity and species diversity of nature must be preserved. Previously, species were categorized as useful or harmful. Now, species diversity, including formerly defined pests, should be protected. Harvesting can only occur when productivity and species diversity are protected. Harvesting cannot negatively impact species diversity. Agricultural and recreational interests are considered equally.
2. **§ 2. Definition of Wildlife:** Wildlife is defined as wild, terrestrial mammals, birds, reptiles and amphibians. Previously, wildlife included only birds and wild mammals. Marine mammals are not included in the definition.
3. **§ 3. Principle of Protection:** Known as the "mirror principle," it reversed the previous rule that it was legal to hunt anything not explicitly protected. Now, the principle is "reversed," meaning wildlife is protected unless specified otherwise. (In Norway, hunting was allowed for 56 wildlife species in 2022.)
4. **§ 4. Wildlife Management Bodies:** Four wildlife management bodies were established: 1) The Ministry, 2) The Directorate for Wildlife and Freshwater Fish

12 https://www.fao.org/faolex/results/details/en/c/LEX-FAOC013835/; https://lovdata.no/dokument/NL/lov/1981-05-29-38

(later Directorate for Nature Management, now the Environment Agency[13], 3) The County Governor (Statsforvalteren)[14] and 4) The municipality. Since 1992, municipalities can organize as they wish, choosing whether or not to have a game board. The landowner, who can organize into larger landowner associations and practically manage many wildlife species through hunting rights and ownership of habitats, is not itself a formal management body.

5. **Poison Use:** The use of poison was discontinued.
6. **Hunter Registry:** Based on the Wildlife Act, a hunter registry was established in 1983. From 1986, new hunters had to pass the national hunter examination in order to hunt and be registered here.

Reflecting on the three areas: 1) the right to hunt, 2) sustaining wildlife populations and 3) respect for individual animals, we see:

1. Landowners have the right to hunt on their land.
2. Sustaining wildlife populations along with their habitats is essential.
3. Great emphasis is placed on ensuring individual animals do not suffer unnecessarily. In a number of court cases, people have been convicted for causing or risking unnecessary suffering to wildlife.

Municipalities became wildlife management bodies under the Wildlife Act of 1981. With the Environmental Protection in the Municipality (MIK) reform in 1992, municipalities received overall responsibility for nature management. The state allocated earmarked funds for environmental leader positions for a three-year period. However, this funding was not sustained. Subsequently, wildlife and nature management tasks have typically been incorporated as a small part of other positions. Various regulations under the Wildlife Act define the municipality's responsibilities. The municipality is the local wildlife authority. The Deer Wildlife Regulation (2016) gives municipalities an important role in managing moose, red deer and roe deer. Municipalities with areas in wild reindeer regions propose members for the wild reindeer board. Municipalities are free to create beaver management plans and

13 A new wildlife law is currently being written. In 2023, game species (except lynx) have been transferred to the authority of the Agricultural Agency (Landbruksdirektoratet) under the Agricultural Ministry (Landbruks- og matdepartementet), while wild reindeer, wolves, wolverines and bears, along with fully protected wildlife species, continue to be managed by the Environment Agency (Miljødirektoratet) which is under the Climate and Environmental Ministry (Klima- og miljødepartementet).

14 From 2010 the County Municipality (Fylkeskommunen) has responsibility for game species (except lynx and wild reindeer) at the county level.

are responsible for retrieving traffic-injured wildlife. Municipalities allocate funds from their own wildlife funds, sourced from culling fees for moose and deer.

An overview of the key actors in Norwegian wildlife management is given in Table 4.2.

Table 4.2: Overview of actors responsible for wildlife management (based on Pedersen et al., 2021c).

<table>
<tr><td>Ministry for Food and Agriculture (LMD)
Primary responsibility for food and agricultural policy, including management of harvestable wildlife species, land management, agriculture and forestry, harvesting, population monitoring and wild reindeer boards.</td><td>Ministry for Climate and the Environment (KLD)
Overall responsibility for the government's climate and environmental policy, including biodiversity, non-game species and predators. KLD oversees non-huntable wildlife species and follows up on wild reindeer habitats and responsibilities.</td></tr>
<tr><td>Environment Agency
Responsible for drafting regulations, providing guidance and information, identifying knowledge needs, prioritizing and funding research, monitoring, and initiatives. Oversees non-game species and wild reindeer hunting, appoints wild reindeer boards based on municipal recommendations, and serves as an appeals body for decisions made by the wild reindeer boards. Responsible for large carnivore management, including lynx (a game species). Overall responsibility for hunter tests and shooting tests.</td><td>Agriculture Directorate
Responsible for the management of nearly all game species (except lynx, with partial authority for wild reindeer).</td></tr>
<tr><td>County Municipality
Regional coordination and guidance responsibility in managing moose, deer and roe deer. Plays a key role as a regional planning authority and is responsible for developing and implementing regional plans under the Planning and Building Act for the 10 designated national wild reindeer areas.</td><td>County Governor
Provides guidance and budget responsibility for wild reindeer boards and serves as an appeals body for municipal decisions. Ensures biodiversity in land management and reviews municipal land-use plans for approval and can formally object to regional plans.</td></tr>
<tr><td rowspan="2">Municipality
Responsible for public deer interests and the rights of hunting rights holders. Sets goals for deer management (excluding wild reindeer), establishes minimum areas, approves hunting districts and allocates culling permits. Approves population plan areas and population plans. A central actor in land management and ensures wild reindeer needs are considered in land-use matters.</td><td>Wild Reindeer Boards
Public bodies with members from municipalities with land in wild reindeer areas, responsible for approving population plans, annual culling quotas and hunting districts, ensuring consideration of wild reindeer in land management. The board is under the instruction authority of the Environment Agency. Tasks are specified in the agency regulations.</td></tr>
<tr><td>Large Predator Boards
These regional boards, along with the County Governors. are responsible for management plans to ensure that goals for large carnivores are met with respect to areas prioritized for predators and those prioritized for livestock. Representatives are appointed by the Ministry of Climate and Environment and, in reindeer districts, the Sami Parliament.</td></tr>
</table>

Private landowners/rights holders	Public landowners/rights holders
Landowners have hunting rights on their own land. Encouraged to organize into population plan areas and develop population plans, which must be approved by the wild reindeer board for wild reindeer and by the municipality for moose, deer and roe deer. Often organized into national organizations, cooperatives and local landowner associations.	State-owned lands (Statskog—State Forest), Finnmark Estate, and municipal properties have the same rights and responsibilities as private landowners. Mountain boards, under the Mountain Act, manage usage rights in state commons. Statskog administers landowner rights and performs management tasks in state commons.
Hunters Hunters carry out hunting and direct culling. The hunter can be the landowner themselves. Hunters can be organized through the Norwegian Association of Hunters and Anglers (NJFF), which is politically independent but engages in political and practical matters related to hunting and fishing and resource management. The association had about 110,000 members in 2022, distributed across around 550 local clubs and 19 regional organizations.	

Table 4.2 does not provide a complete overview of all the actors involved in wildlife management. Here are additional key players:

- **Norwegian Nature Inspectorate (SNO):** Conducts inspections and monitors compliance with wildlife regulations.
- **Norwegian Public Roads Administration and Bane NOR:** Play roles in reducing wildlife collisions on roads and railways, respectively.
- **Norwegian Food Safety Authority:** Responsible for inspecting game meat and ensuring animal welfare standards for harvesting and research.
- **Innovation Norway:** Facilitates the development of industries based on wildlife resources, supporting initiatives that sustainably utilize wildlife for economic growth.
- **Ministry of Justice and Public Safety:** Responsible for firearms legislation and enforcement.

The County Governor (represents the government at the county level) provides guidance and is responsible for the budget of wild reindeer boards and serves as an appeals body for municipal wildlife decisions. The County Governor is tasked with preserving biodiversity in land management and can therefore impose changes or halt municipal and regional plans. Their decisions can be appealed to the relevant ministry. The County Governor plays a role in managing protected wildlife species, geese and large predators, and handles complaints related to deer management.

In connection with the regional reform, several wildlife management tasks were transferred from the County Governor to the county municipalities in 2010. The county municipalities are governed by elected regional politicians. They have been given responsibility for:

1. Management to ensure the harvestable species are not threatened.
2. Collection and quality assurance of some wildlife data for national databases.
3. Guidance for municipalities and rights holders.
4. Distribution of regional wildlife fund resources.
5. Ensuring public access to hunting and fishing.

The Wildlife Fund, established under § 39 of the Wildlife Act, provides Norwegian wildlife management with funds and strength beyond the allocations from the state budget. "All hunters must pay a hunter fee, which goes to a state wildlife fund. Additionally, anyone who harvests moose and red deer must pay a culling fee, which goes to municipal wildlife funds. The revenues from the hunter fee go to the Hunter Registry and the Cervid Registry, Statistics Norway, the National Monitoring Program for Cervids, grants for research and development and wild reindeer boards. Some fund resources are distributed locally via the county municipality and the County Governor."

The Regulations on Municipal and County Municipal Wildlife Funds and Culling Fees for moose and red deer (Viltfondsforskriften 2011) state that municipalities with moose and red deer hunting must establish a wildlife fund. The wildlife fund should promote wildlife management and be used solely for wildlife purposes and not for municipal positions.

There has been some discussion about the use of wildlife funds. Hunters pay the funds, but some of the money has been used for purposes other than hunting and game species. The authors recall when the then Secretary General of NJFF, Stein Lier-Hansen, proposed a "binocular fee" for ornithologists, suggesting that derived funds could be used instead of money paid by hunters to study protected bird species. Author Brainerd remembers similar discussions from the USA, where hunters did not want nonconsumptive wildlife users to pay ("Teaming with Wildlife", see Franklin and Reise, 1996); however, hunters wanted to solely have the honor of financing wildlife measures and lobbied successfully against it.

The wildlife fund has been and remains a very important source for financing wildlife measures in Norway. However, a challenge is that the costs of handling fallen wildlife must be paid by the municipality. Pedersen et al. (2021c) found that half of the municipalities used more than 80%, and the rest used the entire wildlife fund for dealing with traffic-caused wildlife mortalities. They suggest that the responsibility for dealing with traffic mortalities should be transferred to the railroad or highway authorities. This would better facilitate wildlife management in municipalities.

When the Nature Diversity Act was introduced in 2009, the Wildlife Act received a new purpose clause:

> Wildlife and wildlife habitats shall be managed in accordance with the Nature Diversity Act and in such a way that the productivity and species diversity of nature are preserved. Within this framework, wildlife production may be harvested for the benefit of agriculture and outdoor recreation.

NATURE DIVERSITY ACT OF 2009

The Nature Diversity Act[15] replaced the Nature Conservation Act and incorporates the intentions of ratified conventions. The Nature Diversity Act supersedes the Wildlife Act and other legislation.

The purpose of the Nature Diversity Act is "to protect nature, with its biological, landscape and geological diversity and ecological processes, through sustainable use and conservation, so that it provides the basis for human activity, culture, health, and well-being, now and in the future, also as a basis for Sami culture."

The purpose of the Nature Diversity Act is significantly broader and more complex than previous laws. According to this Act, all types of natural habitats should be protected where they naturally occur, and biodiversity and ecological processes should be preserved. The long-term viability of species and their habitats and genetic diversity should be ensured. Ecosystems, along with their structure, function, and productivity, should be preserved to the extent that is reasonable. People must take all reasonable precautions to avoid harming biological, geological and landscape diversity. Measures can be implemented to protect prioritized species and counteract invasive species. The administrative evolution from categorizing animals as pests or useful to holistic conservation has been an international development. Mykra et al. (2005) show a similar progression from medieval times to the present in Finland.

Authorities can still grant permission for measures and interventions, provided that the requirements of the Act are met. Therefore, water and wind power developments can be approved if politicians deem it necessary. In 2022, the Norwegian government expressed a desire to reassess the hydroelectric power potential in permanently protected watercourses.

The Brundtland Commission defined sustainable development in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (NOU, 2009:16, p. 9). The Nature Diversity Act does not directly define "sustainable use", but it does indicate what is meant in various sections. Section 5 addresses management goals for species that arrived in Norway on their own. The goal is to preserve the species and their

15 https://www.regjeringen.no/en/dokumenter/nature-diversity-act/id570549/

genetic diversity in the long term and ensure that the species exist in viable populations within their natural distribution areas. As far as it is necessary to achieve this goal, the ecological functional areas of the species and the other ecological conditions they depend on are also preserved.

Ecological functional areas are defined as areas that fulfill an ecological function for species. This can include central functions in the life cycle of the species located in specific areas. Ecological functional areas are used in the description of wild reindeer areas. We can wonder if any part of the wild reindeer areas is not an ecological functional area. Wild reindeer are nomadic and can live in one area at one time and in another area at another time. Framstad et al. (2018) discussed the concept of ecological functional areas and concluded that the term can be useful in some cases.

Section 16 addresses harvesting: "Harvesting can only be permitted when the best available documentation indicates that the species produces a harvestable surplus".

This can be a problematic formulation. We have little knowledge about the production of many of the game species. Pedersen et al. (2021d) assessed the population status and development trends for the currently huntable small game species and wrote: "For some other bird species and most mammal species, the population information is incomplete." For example, we know little about whether hazel grouse (*Tetrastes bonasia*), rock ptarmigan, Eurasian jay (*Garrulus glandarius)* and stoat (*Mustela erminea*) produce a harvestable surplus. We have to rely on the assumption that, based on their biology, they should tolerate hunting, that they have been hunted for a long time and that they seem to be doing well. However, a long-term decline in hazel grouse harvests in Norway (Statistics Norway[16]) and Sweden (Jansson, G., pers. comm.) may indicate that monitoring and research are necessary to evaluate its status as a game species relative to the Nature Diversity Law § 16.

The concept of a harvestable surplus is an interesting one. If regulated hunting of golden eagles was permitted, the number of non-territorial juvenile eagles would likely decrease without reducing the number of occupied territories; perhaps production would increase due to less competition for space and food. Furthermore, when a weak spring population of a grouse species has its production destroyed due to weather or predation, is there then a harvestable surplus? Regardless, the golden eagle is protected and grouse hunting is up to the landowner to decide, as long as the species is classified as game.

16 https://www.ssb.no/statbank/table/03886

Furthermore, § 16 states: "When deciding whether to permit harvesting and the method of harvesting, consideration shall also be given to the species' function in the ecosystem and the impact harvesting may have on biological diversity in general. Consideration shall also be given to the species' significance for industry or recreation, harvesting tradition in the relevant area, and the damage caused by the species." It is therefore not easy to know which species should be harvestable. In the draft hearing for new hunting seasons in 2017, the Environment Agency proposed opening hunting for common blackbirds (*Turdus merula*) because they believed that all available information indicated that the blackbird produced a harvestable surplus. The proposal led to strong protests, which the Environment Agency heeded. We believe that the Environment Agency thought along these lines: the blackbird is doing well and tolerates hunting. Blackbird hunting has recreational significance for very few. Many find recreational joy in hearing the blackbird sing, and many of them do not understand that hunting a harvestable surplus would not affect how many birds will sing the following year. Thus, it was easier to protect than to allow hunting of a species that produces a harvestable surplus. The opinions of people and interest groups often have more significance than biology when determining whether a species should be hunted or not.

Members of the parliamentary committee that reviewed the Nature Diversity Act were aware of the challenge of demonstrating a harvestable surplus and wrote that it was necessary to avoid: "… hunting and fishing of species unintentionally being prohibited due to management challenges in producing documentation that a species produces a harvestable surplus" (Innst. O. 100 (2008–2009)). The committee also wrote that: "… the best available documentation indicating that the species produces a harvestable surplus … should be based on the knowledge that actually exists." We interpret this as meaning that species can be hunted according to the law despite lacking detailed documentation on population development.

In Denmark, it seems that the requirement for documentation is stronger. The number of stone martens (*Martes foina*) harvested has decreased from nearly 4,000 to nearly 2,500 over 18 hunting seasons. The decline may be due to less interest in hunting, but since there is no documentation that hunting is sustainable, the Wildlife Management Council has recommended to the Danish minister to stop the hunting until such documentation is obtained (Sunde et al., 2022).

THE FORTHCOMING WILDLIFE RESOURCES ACT

In the summer of 2024, a public consultation note was sent out jointly by KLD and LMD for the Wildlife Resources Act which will replace the current Wildlife Act of 1981. It emphasizes that wildlife is a resource.

The purpose clause states:

> The law aims to ensure sustainable management of wildlife so that nature's productivity and species richness are preserved and animal welfare is safeguarded. Wildlife shall be managed in accordance with the Nature Diversity Act and the Animal Welfare Act.

Within this framework, wildlife resources can be harvested through hunting and trapping and regulated through culling and other management of wildlife.

This new law builds on previous Norwegian laws. Landowner rights are emphasized, wildlife resources are secured as before and the most important changes are increased respect for individual animals and the clarification of sections. The bill also clearly distinguishes between hunting animals under the Wildlife Resource Act and culling pests under the Nature Diversity Act.

The consultation note elaborates on responsible hunting and trapping practices. Wildlife should not be subjected to unnecessary stress or strain. However, it emphasizes that what constitutes unnecessary stress or strain will depend on how these aspects are weighed against the utility of an action. Furthermore, it states that what is considered humane depends, among other things, on the species being hunted or trapped. Thus, there is room for some discretion.

The consultation asks whether it is sufficient to use firearms and ammunition suitable for harvesting wildlife in a safe and humane manner or whether other means (such as archery equipment) can be used. It opens for duck hunting by the Sami people in the spring and proposes that the closed season during the Christmas period should continue. The bill will prohibit the use of technology to locate game, including drones and digital rifle scopes with night vision, barring exceptional situations. However, we interpret the proposal to allow the use of motor vehicles for hunting and tracking animals along roads. This can simplify culling under the Nature Diversity Act, but it is difficult to understand how it would be permitted during hunting. It will be interesting to see how the legal text turns out. The bill opens for the use of bounties and population-regulating measures under special conditions. The word "natural" is used in the bill, even though it can be difficult to know what "natural" means. The bill is comprehensive and well-prepared. As of this writing, it still has not become law.

OTHER LEGISLATION

There are a number of other laws that have some bearing on how wildlife management and hunting are conducted.

The Animal Welfare Act (2009)[17] promotes respect for and the welfare of animals. The law applies not only to wildlife, but also to livestock, fish and marine mammals. The law states that animals have intrinsic value regardless of the utility they may have for humans. Animals shall be treated well and protected from the risk of unnecessary stress and strain. The law has its own section, § 20, on trapping, hunting and fishing. The most important point here is that hunting, trapping and fishing shall be conducted in an animal welfare-appropriate manner. Furthermore, the government may issue detailed regulations in adherence with this law.

The Dog Ownership Act (2003)[18] has rules about leash requirements (April 1–August 20) and prohibiting dogs from chasing wildlife during the spring and summer breeding seasons for wildlife, with exceptions given in August in some places for training hunting dogs or conducting grouse surveys off leash prior to the opening of the small game hunting season in September. Dogs for tracking injured wildlife can be used during the leash requirement period. Important points here are that training, hunting trials and training require landowner consent. Under certain conditions, hunting dogs can be euthanized or required to be euthanized by someone other than the owner.

The Firearms Act[19] (1961, last amended in 2015) provides rules about how to acquire hunting firearms, lending firearms, and how hunters can bring firearms in and out of the country. In several recent court cases, hunters have been convicted for storing firearms in cars, under beds, or with the key in the gun cabinet door. It is worth noting that when a person is sentenced by the court to lose hunting rights for two years, the police can say that the person is not fit to have firearms for an indefinite period. A two-year sentence without hunting rights can, in practice, lead to many years without firearms, depending on police discretion. Based on newspaper articles, it is easy to get the impression that police decision criteria vary between police districts, from old-fashioned sheriff's discretion to meticulous willingness to weed out as many firearm owners as possible..

Other important laws pertaining to wildlife management and hunting include but are not limited to the Mountain Act, the Forestry Act, the Finnmark Act, the Planning and Building Act, the Nature Surveillance Act, the Motor Traffic Act, and the Svalbard Act. Recreational seal hunting is regulated by the Fisheries Department and Directorate but is not included here as seals are not considered "wildlife" or "game" under the current Norwegian Wildlife Act.

17 https://lovdata.no/dokument/NL/lov/2009-06-19-97

18 https://lovdata.no/dokument/NL/lov/2003-07-04-74

19 https://lovdata.no/dokument/NL/lov/2018-04-20-7

IMPORTANT REGULATIONS IN NORWAY

The laws provide principles and overarching rules. How principles and overarching rules should be understood in detail at any given time is shown in regulations. Regulations do not need to be approved by the Parliament, and the issuing authority can change them as needed. The Environment Agency issues the cervid regulation, which sets the rules for the management of cervids within the principles set in the Wildlife Act. The municipality issues regulations on minimum areas for moose when determining quotas. A regulation is written by an authority and applies to all people in a given area. Regulations can be changed so often that what is written in books is often outdated—regulations should be checked online when they are to be used.

Cervid Regulation

The Cervid Regulation (2016)[20] elaborates on how wild cervids should be managed. The municipality is responsible for the management of moose, deer and roe deer, while Norway has a special international responsibility for wild reindeer, which are managed by reindeer boards appointed by the Environmental Directorate. The regulation emphasizes the county's advisory role, the municipality's responsibility, the hunting rights holders' rights and the State Administrator's role as the legal authority. Landowners must organize themselves into hunting areas with the minimum area required to obtain a harvest permit.

The municipality shall develop goals for the trajectory, size and structure of the populations of the responsible species. The municipality should select indicators to assess whether the population sizes correspond to the goals for grazing pressure, collisions, or other societal interests. Indicators for the structure of a population can be the required observations hunters make during the hunt, such as the so-called "seen moose" system (see Chapter 7). The goals shall be developed and adopted as rolling municipal and regional plans. The plans should be developed in close dialogue with stakeholders such as landowners and hunting organizations. The regulation facilitates inter-municipal cooperation to manage according to cervid population boundaries, not administrative boundaries that the animals do not recognize.

An important goal of this regulation is to manage cervids in large landscape units. The regulation facilitates that hunting areas that wish to, alone or together with other hunting areas, manage cervids according to multi-year harvest plans in

20 https://lovdata.no/dokument/LTI/forskrift/2016-01-08-12

population plan areas, which should include the population's annual ranges, in line with municipal goals. Municipalities enter data into the cervid register, which is a national database and case management tool. See Chapter 12 for details regarding cervid management in Norway.

Regulation on the Management of Large Predators[21] (2005, amended 2021)

This regulation provides detailed rules on how large predators should be managed, including culling, hunting, requirements for hunters and appeal opportunities. It aims to ensure sustainable management of lynxes, wolverines, bears, wolves and golden eagles, but to "also safeguard considerations for commercial activities and other societal interests. The management shall be differentiated so that the consideration for different interests is weighted differently in various areas and for the different predator species. The regulation shall ensure management that emphasizes predictability and local participation."

The regulation defines relevant terms. These are:

- **Quota hunting:** Ordinary hunting of a specific number of individuals of a wildlife species under the authority of the Wildlife Act § 9, cf. the Nature Diversity Act § 16, where the quota is set by public authorities. Currently, lynx is the only species that qualifies for quota hunting since it is classified as a regular game species.
- **Licensed culling:** Culling of a specific number of individuals of a protected wildlife species under the authority of the Nature Diversity Act § 18, first paragraph b) and c), where the quota is set by public authorities and requires that the hunter is registered as a licensed hunter in the Hunter Register to participate. Currently, the wolf, bear and wolverine are classified as protected species and can be culled under this regulation to achieve management goals.
- **Large Predator Board:** Public wildlife body established under the authority of the Wildlife Act § 4 with responsibility for the management of lynx, wolverine, bear and wolf in a region (see Table 4.2 and Chapter 15).

The regulation indicates how the country is divided into eight management regions for predators, each with its own population targets and predator board proposed by the county council and appointed by the Environment Agency. The regulation outlines the population targets for the various species, what the predator committees

21 https://lovdata.no/dokument/SF/forskrift/2005-03-18-242

can decide, and states that regional management plans should be developed. The County Governor[22] serves as the secretariat for the predator committee and also has the authority to initiate culling of individual animals.

Regulation on the Management of Beavers (Beaver Regulation 2017)[23]

Previously, beaver management was included in the Regulation on Cervids and Beaver Management. Now a separate regulation has been developed for beavers. The purpose of this regulation is to contribute to the management of beavers in accordance with the management goal for species in the Nature Diversity Act § 5. The regulation shall facilitate local and sustainable management with commercial and recreational utilization of wildlife resources. At the same time, the regulation shall help prevent unnecessary damage and inconvenience to other societal interests.

Management is a municipal responsibility. The municipality shall adopt goals for the development of populations in accordance with the Nature Diversity Act. Few requirements are set. The municipality can set quotas and require reporting from hunters and those with hunting rights when necessary. The beaver is no longer threatened and can be managed locally like grouse without a quota during the hunting season. The background for this is the extensive research at the University of South-Eastern Norway in Bø (see Parker & Rosell, 2012). Generally, the harvest is so low that the cost of management plans is often greater than the benefit.

Regulation on the Conduct of Hunting, Culling and Trapping (Hunting Conduct Regulation 2002)[24]

The regulation ensures that hunting and trapping can occur without causing unnecessary suffering to wildlife or exposing people, livestock, or property to danger. The regulation provides hunters and trappers with most (but not all) public rules on hunting, culling and trapping.

This regulation also defines quota hunting and licensed culling as two different concepts. Quota hunting is ordinary hunting with a quota for game species of large carnivore (lynx), while licensed culling is damage-motivated culling of a specific number of individuals of protected species (wolf, bear, wolverine, golden

22 https://www.statsforvalteren.no/en/
23 https://lovdata.no/dokument/SF/forskrift/2017-04-26-519
24 https://lovdata.no/dokument/SF/forskrift/2002-03-22-313

eagle). Even though culling is not defined as ordinary hunting, licensed hunters must also have permission from the landowner. The regulation indicates hunter requirements including age limits, training, examination, fees and documents needed during hunting.

The regulation provides rules for firearms, magazine capacity, type of ammunition and shooting tests, and contains rules for the use of dogs during hunting, culling and tracking. There are special requirements for hunting big game and for the hunting leader. A separate chapter in the regulation addresses trapping. It is legal to trap 11 mammal species and seven bird species, and there are special requirements for traps that capture wildlife alive and those that kill wildlife. The regulation includes instructions, agreements and information.

Regulation on Depredation Culling, Dead Wildlife and the Use of Wildlife in Captivity, Research and Zoos (Wildlife Regulation 2020)[25]

The Wildlife Regulation governs the capture of wildlife, depredation culling and other removal of wildlife, keeping wildlife in captivity, what to do with escaped wildlife, releasing wildlife into nature and how to handle dead wildlife. There is a register of species of dead wildlife that belongs to the wildlife fund, while the finder can claim other dead wildlife.

Regulation on Baiting and Feeding Wildlife (Feeding Regulation 2019)[26]

It is not legal to feed wild boar, lynx, wolf, brown bear or golden eagle. It is legal to use bait in connection with trapping and hunting of certain species.

Regulation on Hunting and Trapping Seasons and Collection of Eggs and Down[27]

The regulation specifies which species can be hunted and from which eggs and down can be collected, as well as where and when. The regulation is revised every five years following an assessment of population status and development trends for small game species (Pedersen et al., 2021d) and in consultation with stakeholders.

25 https://lovdata.no/dokument/SF/forskrift/2020-04-01-565
26 https://lovdata.no/dokument/SF/forskrift/2019-12-17-1878
27 https://lovdata.no/dokument/SF/forskrift/2022-01-21-128

NORWEGIAN LEGAL PRACTICES REGARDING WILDLIFE ISSUES

We have reviewed a number of recent Norwegian court cases involving wildlife. The rulings underscore the shift from a cost-benefit perspective to the notion that all nature has intrinsic value. In cases of illegal large predator hunting in Hedmark in the 2010s, it is clear to us that poachers received support from many who did not move to the city and who are rooted in the old view that useful animals should be protected and harmful animals should be removed by all means. The district court judge in a wolf hunting case in 2015 told us that his father, an over 90-year-old man from Hallingdal, said: "Interesting judgment to read: Before we were supposed to protect livestock, now we are supposed to protect predators." It is also interesting to see that people have been convicted for taking long shots at wild reindeer. Successful shots at long ranges would previously have given the hunter high status. However, now the court could convict someone for taking such a long shot, even in cases where it actually was killed rather than wounded.

Author Storaas observed a trial against a bear poacher in Finnskogen in Southeastern Norway. The prosecutor represented the new attitude that led to the regulation that bears should be protected. The audience and regional newspapers represented the old local attitude that bears were dangerous pests that should be removed. They supported the bear shooter even though both the district court and the appellate court found it proven beyond all doubt that the shooter had broken Norwegian law. In cases of spring duck hunting in Karasjok in Northern Norway, we can observe similarly opposing views between university-educated prosecutors who adhere to Norwegian regulations and tradition-bound Sami who have hunted ducks in the spring for generations. For example, two duck hunters were acquitted in the Inner Finnmark District Court (2020) although they were hunting outside the limited spring hunting season, because the two lay judges believed it was in accordance with Sami customs. The professional judge disagreed, the prosecutor appealed the case and the Hålogaland Court of Appeal (Hålogaland Lagmannsrett, 2020) ruled that since the spring season was strictly regulated to accommodate Sami tradition, the hunters were convicted since they had not adhered to it.

From a wildlife management perspective, some rulings can seem strange. On July 12, 1995, the Mid-Trøndelag District Court (Midt-Trøndelag Herredsrett, 1995) issued an interesting judgment. A grazing association in Selbu demanded compensation for 20 cattle they believed had died due to bear attacks. They found no tracks, feces, or hair from bears, the bears had not bitten or eaten the cattle, but there was a hypothesis that the bears could have tried to rape the cows, leading to death. The grazing association was awarded compensation for 16 cattle.

"The court based its decision on the regulations of March 8, 1993, which require a predominant probability that the damage was caused by predators rather than all other possible causes combined. Although there were no clear and certain signs of bears in this case, it does not exclude the possibility of compensation. There was no significant probability of alternative causes of damage." It is difficult to understand that the court concluded that it was specifically bears that caused the deaths, without a shred of evidence. Based on this ruling, one could argue that all livestock deaths that occur without any evidence of cause should be compensated as predator kills. The EnvironmentAgency did not bother to appeal this case. We note that both a biologist and a veterinarian were completely certain it was a bear, without a shred of evidence. Therefore, it may not be surprising that the court decided to show leniency and award the farmers compensation from the state. Nevertheless, we as educated wildlife biologists think when we read the judgment afterward that these 16 deaths, which were compensated for, are highly unlikely to have been caused by bears. We see it as a great achievement that the biologist and veterinarian managed, without any form of evidence, to pull the bear out of the hat and convince the court in favor of the farmers.

In 1995, a hunter was convicted for shooting at wild reindeer from an extreme distance by the Eidsivating Court of Appeal (Eidsivating Lagmannsrett, 1995), and in 1996, three were convicted for long shots at animals that were moving (Gulating Lagmannsrett, 1996). The chance of wounding was too high for the shots to be justified. However, the hunter was acquitted for a head-on shot to the head of a reindeer buck at a distance of 140 meters. The hunter had a bipod on the rifle, was a skilled shooter, and the buck died immediately (Nord-Gudbrandsdal Tingrett, 2020). If the buck had been wounded after a shot to the head, the hunter would likely have been convicted. Bjerkvik (2009) discusses the requirements for considerate hunting under the Wildlife Act, provides examples of court rulings, and details what is meant by the requirement that hunting must not cause unnecessary suffering to wildlife.

Several videos posted online by hunters who consider their filmed activities to be ethically high-quality have led to convictions. Laws have changed, and norms follow the laws. The modern view of nature trumps the old utility culture in rural Norway. Particularly regarding the value of wolf conservation, there is significant disagreement between old and new views. The Agricultural Center Party wanted to eradicate wolves from Norway, while the other parties wanted to preserve a few animals. Working politically for what one believes in is right and good. However, one must remember that a small portion of the people in Norway hunt, few live in wolf areas and fewer own livestock. The perception of the majority that hunters adhere to laws and norms is crucial for the future of hunting in Norway.

AUTHORS' REFLECTIONS

Norwegian wildlife legislation addresses who should have hunting rights, the protection of wildlife resources, and ensuring that individual wildlife does not suffer unnecessarily. We present a history of the historical progression of wildlife law in Table 4.3. There is no universal rule for who should have the right to hunt. In Norway, ancient chiefs claimed property rights to land, hunting with dogs, and hunting moose, red deer and beavers, and codified it into legal texts. In 1899, the principle of free hunting (without dogs) for everyone was amended to exclusive hunting rights for landowners by an upper-class Parliament. Access to hunting is generally good in Norway. Future hunting opportunities for the general public can be secured through public ownership of forests and mountains distributed across the country.

The view on the protection of wildlife resources has shifted from distinguishing wild species between useful and harmful to ensuring that all native wildlife and their habitats are conserved or protected. In 1845, it was important to eradicate all large predators and birds of prey, in order to freely graze 100,000 herds of livestock on the open range for the need for young children as shepherds (Richardsen, 2014). The purposes of the hunting laws were so obvious that there was no need for purpose clauses: harmful animals should be removed, and useful wildlife should be conserved for harvest. As recently as the Hunting Act of 1951, which was in effect until 1981, animals were divided into these useful and harmful categories. The laws up to and including 1951 were hunting laws; in 1981, a Wildlife Act was introduced, and now the Wildlife Act is a subordinate law under the Nature Diversity Act. These changes reflect the fact that people have moved from agriculture and rural areas to offices and factories in towns and cities. To put it bluntly, the legislative changes reflect the fact that grouse and chickens went from being important food that needed protection from hawks to meat that can be bought in the store, while hawks are now protected and can be enjoyed on TV.

Administrative wildlife authorities are no longer concerned with the detailed management of game species as long as landowners manage game populations such that they are neither scarce nor overabundant. In 2018, the Ministry of Agriculture and Food took responsibility for game species as a crop the land produces. It will be interesting to see if this leads to changes in state management interest.

Exciting challenges for the legislation arise when animals previously considered pests are protected and recover to abundance such that they can strongly and negatively impact other species. The Norwegian Nature Inspectorate (SNO) kills critically endangered wolverines and their young to prevent depredations on domestic sheep. What should be done when abundant populations of protected otters take critically endangered Atlantic salmon (*Salmo salar*)? What if protected Northern harriers (*Circus hudsonius*) kill nesting red-listed ptarmigan? And what should be done if red foxes and martens take so many forest bird nests that these species also become rare, to the detriment of people and their predators such as eagle owls and goshawks (*Accipiter gentilis*)? Or what if goshawks threaten red-listed hares? And what if protected polar bears (*Ursus maritimus*) raid eider colonies on Svalbard year after year, or groups of thriving killer whales (*Orcinus orca*) kill critically endangered Bowhead whales? Or do white-tailed eagles kill endangered black-legged kittiwakes?

We can also consider the wild boar, which is returning to Norway after possibly being eradicated by humans. When wild boar, a species that originally occurred on the Scandinavian Peninsula in ancient times, wander into Norway from Sweden (where they were reintroduced but declared native) should they be eradicated for economic reasons or for conservation purposes? And what about the Arctic fox? The Nature Diversity Act states that we should preserve ecological processes. Is it illegal under this legislation to oppose the ecological processes that threaten to eradicate the Arctic fox due to rising temperatures?

Explicit consideration for animal welfare was first included in the Hunting Act in 1951. Historically, hunters emptied their rifles into wild reindeer herds. It was much easier to kill wounded animals than healthy ones. The authors have friends who were scolded by the old-timers for not adjusting their open sights and shooting into the herds at long distances. "As long as there's lead in the air, there's hope for meat," they said. This view has changed. Before, the hunter fired in the hope of getting food, but now he refrains from firing out of fear of wounding. Who should have the hunting rights is a result of previous power relationships. The expansion of the concept of what is wildlife, the protection of wildlife and requirements for ethical hunting have emerged as a consequence of societal development over time.

Table 4.3: Some important events in Norwegian wildlife management

Year	Event
1274–1276	Magnus Lagabøte's land laws adopted at various regional assemblies
1600s–1700s	Various regulations from the government in Copenhagen
1814	New Norwegian Constitution
1818	Total protection of moose (one year)
1845	Law on the Eradication of Predators and the Protection of Other Wildlife
1863	Establishment of hunting seasons for grouse species that were earlier hunted year-round.
1871	Norwegian Associations of Hunters and Anglers (NJFF) founded

(*Continued*)

Table 4.3: (*Continued*)

Year	Event
1899	Hunting Act, landowner's exclusive right to hunt useful wildlife
1900	Universal suffrage for men
1913	Universal suffrage for women
1932	Landowner's exclusive right also to birds of prey and predators, end of game hunting for black grouse and capercaillie
1951	New Hunting Act, wildlife committees, ethics, wildlife insurance fee
1965	Directorate for Hunting, Wildlife Management and Freshwater Fishing
1968	Protection of golden eagle and white-tailed eagle
1971	Protection of wolf
1972	Ministry of the Environment
1974	Directorate for Wildlife and Freshwater Fish
1975	Ramsar Convention (Wetlands Convention) ratified by Norway
1976	CITES (Washington Convention) ratified by Norway
1981	Wildlife Act, what is not defined as huntable is protected
1985	Directorate for Nature Management
1985	Bonn Convention (1979) ratified by Norway
1986	Bern Convention (1979) ratified by Norway
1987	Research separated from management in the Directorate to NINA
1993	Rio Convention (1992) ratified by Norway
2009	Nature Diversity Act
2016	New Cervid Regulation
2022	UN Nature Agreement, Kunming-Montreal Global Biodiversity Framework
2024	Public consultation on new Wildlife Resource Law, meant to replace the Wildlife Law of 1981

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5. Wildlife conservation in other countries

In this chapter, we will examine the main principles for how wildlife is managed in several different countries. We have chosen to look at Kenya, Scotland, the USA, Southern Africa, the Netherlands and Switzerland because their social systems and fundamental legal conditions are different from Norway. Kenya and Southern Africa have increased human populations, poverty and pressure on nature, but still have large wildlife resources that they have chosen to manage in completely different ways. The USA is a very large union of states with highly varied nature and abundant wildlife, and they spend significant resources on wildlife management based on some overarching principles. In Europe, Scotland and Switzerland still have areas with good wildlife populations and have chosen to grant hunting rights to completely different groups. The Netherlands is an example of a densely populated country with a lot of cultivated land, where hunting of a few species is a special activity that few participate in. At the end of the chapter, we compare Norwegian hunting culture to those of these other European countries.

We include a lot from the USA and Southern Africa because the USA can teach us something about financing wildlife management and overarching population management, and Southern Africa about how economic value can protect wildlife. The purpose is to show that wildlife can be managed according to different regulations as a background for how Norwegian wildlife management can develop.

Most countries agree on protecting nature and have joined international conventions that set boundaries and rules for nature management. However, there is a wide range of approaches to how wildlife is managed around the world. Wildlife can be either completely protected, managed for the benefit of the general population, or be the basis for large commercial industries. Very roughly, we envision that wildlife can be preserved according to at least three ways of thinking: 1) wildlife has intrinsic value—and it is our duty to preserve it regardless of economic value or utility, 2) wildlife should be enjoyed by both poor and rich through nature experiences and hunting and 3) wildlife should be a resource that is economically beneficial to preserve.

KENYA—ALL WILDLIFE IS PROTECTED

Kenya is a fantastic wildlife country, and in the Maasai Mara National Park, one can still experience enormous wildlife densities. Tourism accounts for 10% of the gross national product and is the second-largest economic sector. It is a major source of foreign currency, and 75% of revenues are derived from national parks (Udoto, 2012). When the British colonized Kenya in 1895, the population was low—around 4 million. By 1955, it had increased to 7 million, and in 2024, there were 56 million. Based on age structure and birth rates, the population is projected to reach 85 million by 2050 (Worldometers, n.d.). Nearly 73% of the population live below or are at risk of falling below the poverty line (UNDP, 2023). The pressure on natural resources is great.

Kenya was previously one of the most sought-after safari countries for big game hunters. However, due to declining populations, elephants (*Loxodonta africana*) were protected in 1973, and all big game hunting was banned in 1977 (Mwaura, 2016). The ban came after overwhelming poaching of elephants, white rhinos (*Ceratotherium simum*) and black rhinos (*Diceros bicornis*) and pressure from international animal welfare organizations, not due to legal hunting. In 1972, Kenya issued between 19 and 34 rhino permits, but over 1,000 rhino horns were imported to Hong Kong from Kenya (Holechek & Valdez, 2018). Despite the hunting ban, populations of elephants, lions (*Panthera leo*) and rhinos decreased by 70% outside national parks and by 40–70% within the parks (Holechek & Valdez, 2018).

The response has been stricter penalties. Kenya's latest wildlife law, The Wildlife Conservation and Management Act of 2013, states that all sports hunting, hunting for food, and hunting for the sale of wildlife are strictly prohibited. Section 96 states that a person who engages in sport hunting of species listed as endangered (such as black rhino and sable antelope (*Hippotragus niger*)) shall receive no less than a fine of at least 20 million Kenyan shillings (approximately 2 million Norwegian kroner), life imprisonment, or both. One million shillings and two years in prison are the minimum penalty for sport hunting. Many different conservation organizations cheered the penalty level and the fact that wildlife would now be protected (Bonham, 2014).

Tourists flock to the wildlife-rich national parks. Outside the parks, however, local inhabitants experience only economic disadvantages with wildlife. The title of the editorial in the online magazine *African Indaba* when the new law came out was "Wildlife Loved to Death" (Martin, 2014). The editor argued that total protection was a failure and that wildlife would be well taken care of if managed locally as a target for safari hunting and food. The editor admits, however, that there is a very big challenge with corruption.

SCOTLAND—UPPER-CLASS HUNTING

The United Kingdom consists of England, Wales and Scotland, and the legislation varies between the countries. The first wildlife laws date back to the time of William the Conqueror. The Norman upper class wanted the wildlife for themselves, and at times, there was a death penalty for killing the king's deer (Hanawalt, 1988). There are broad hunting seasons for huntable species but strict rules on who can own and use firearms. No one owns the wildlife (*res nullius*), but the landowner has the hunting rights. There are no overarching rules for how many individuals of huntable species can be harvested; it is up to the landowner. However, in Scotland, the Public Deer Commission, which is part of Scottish Natural Heritage, can cull deer populations that cause damage, regardless of who owns the land (Putman, 2010; Pepper et al., 2020).

Scotland was divided between clans and used for small-scale agriculture. After Scottish rebels lost to the English at the Battle of Culloden in 1746, the clan system was abolished, and the land was transferred into a few wealthy hands. Those living in the Highlands became tenants. There were very good prices for sheep wool. Landowners evicted the tenants, cleared the forests and focused on large flocks of sheep and wool production. Thousands of people were forced to emigrate, and many went to America. After the Napoleonic Wars and the establishment of wool production in Australia and New Zealand, wool prices fell. The Scottish Highlands were by then quite depopulated, and the owners developed hunting estates. They hunted Scottish red grouse and red deer, and they fished for Atlantic salmon. Today, there are around 250 hunting and fishing estates covering nearly 20,000 km^2. To ensure nature conservation and provide more access to the landscapes, national parks were established in the 2000s, non-profit organizations bought properties and the Scottish Parliament passed laws ensuring the public access to walk on private properties (Holl & Smith, 2007; Hobbs, 2009; Morgan-Davies et al., 2015).

Hunting estates have employed gamekeepers who manage game habitats, trap and shoot predators, organize hunts and guide visiting hunters. We will illustrate the work on hunting estates through our meetings with the head gamekeeper at the Glen Tanar estate, Jimmy Oswald, in the 1980s and onwards. Hunters want good food, whisky, social entertainment and plenty of game. "I provide the game," said Jimmy. A long walk on week-old tracking snow did not reveal a single red fox track, but Jimmy indicated fox snares in holes in fences and other places where the fox would easily go. If fox tracks were discovered, a warning was issued, and gamekeepers from neighboring estates would come together to catch the fox. We also understood why it is practical for right-handed people to have the steering wheel on the right side. If Jimmy saw a carrion crow (*Corvus corone*), he would place a cushion on the car mirror, lay the rifle in position and shoot it off its perch. He found a dead crow and hid it under a stone, wondering if it was illegally killed with poison. At night, he looked for foxes with a spotlight from the car. Perhaps due to the lack of foxes, there were far too many European rabbits (*Oryctolagus cuniculus*) from an agricultural perspective. Jimmy trapped rabbits in snares, in pit traps and released ferrets into rabbit holes and we shot rabbits when they ran out.

The most prestigious hunt has always been drive shooting for red grouse. Drive shoots require a minimum of 60 red grouse per km^2. To achieve such high grouse densities, predator control is absolutely necessary. In addition to predator control, managers manipulate red grouse habitat by annually burning heather (*Calluna vulgaris*) in narrow strips. This provides access for red grouse to regenerating heather for food and remnant mature heather as cover. Since British grouse moors are usually below the tree line, managers must continue this practice to prevent forest encroachment. When the heather moors are managed for grouse and foxes and crows are removed, densities become high. At high densities, parasites spread easily. Grouse need grit, which is scarce in many grouse moors. Therefore, gamekeepers lay out grit containing medicine against intestinal worms (*Trichostrongylus tenuis*). Red grouse densities can thus remain high; in Northern England, the population density on estates during the period 2010–2014 was around 325 grouse per km^2 in August (Game & Wildlife Conservation Trust 2016). Red grouse researchers that we have met have complained about such dense populations because other, lesser known diseases have emerged. Red grouse density increased to an average of over 400 per km^2 but has fallen to nearly 100 per km^2 after bad weather during hatching in the last four years (Game & Wildlife Conservation Trust 2022, p. 31), but is still far above the 60 per km^2 needed to organize driven hunts.

During the hunt, the terrain is divided into fields where it is easy to drive the grouse toward a row of posts behind breastworks in the open terrain. The hunters are driven in offroad vehicles to the posts, and each hunter, or shooter, has two shotguns and a loader. The drivers form a line and flush grouse that fly over the heads of the shooters, who shoot and receive a newly loaded shotgun from the loader. The hunts have long traditions; the catches are recorded and can be very large. Lord Walsingham, on August 30, 1888, with the help of two loaders and three shotguns, bagged a total of 1070 red grouse that 40 drivers sent over him on Blubberhouse Moor in Yorkshire. On the grounds of Littledale and Abbeystead Beat in Lancashire, eight men shot 2,929 red grouse on August 12, 1915, and the retrievers picked up 236 more birds the next day. Lord Ripon bagged 97,503 grouse throughout his lifetime, which is a world record (Perto, 2013). The English count red grouse in braces (pairs), and in 2015 the price for shooting a brace was around £180, in addition to the rental for a hunting weekend, which could vary around

£50,000. The gross income associated with grouse hunting has been estimated at around £2 billion (Warren, 2015).

It is difficult to achieve desirable densities of red grouse if marsh harrier populations are allowed to thrive. Many marsh harrier pairs can nest close to each other when there is enough prey available, which there is on grouse moors. Nevertheless, there are few marsh harriers on the grouse moors, probably because the gamekeepers cull them. Thompson et al. (2016) believed that the negative environmental consequences of intensive grouse management are too great and that drive hunts should be ended. Sotherton et al. (2017) argued that there are so many benefits of driven hunts for the landscape and other species that they should continue. Sotherton et al. (2017) also believed that compromises should be found so that the marsh harrier can be managed sustainably, but far below potential carrying capacity, but this proposal has not received support from hunting opponents.

Jimmy Oswald monitored the capercaillie population, worked to ensure that forestry practices were as capercaillie-friendly as possible and organized drive hunts for capercaillie cocks. Hens were not to be shot. He removed fences to prevent the birds from flying into them and dying. Necessary fences were covered with rolls of vertical wooden sticks attached to steel wire to make them visible to the birds (Baines & Andrew, 2003). In 2001, the capercaillie was completely protected due to declining populations (Scottish Wildlife Trust, n.d.), but Jimmy continued with the measures. The black grouse population was too unstable and moved around too much in small flocks for managers to organize drive hunts on this species.

Jimmy was more concerned with the grouse species than red deer. However, deer hunting was also important for the economy; now 100,000 red deer are harvested annually, and the Scottish Environment Protection Agency (SEPA) has written a comprehensive report on deer management (Pepper et al., 2020). Jimmy sold hunts for red deer stags. A stalker, a professional hunter, would take the client out, find the deer in the open landscape and then sneak up and shoot them, similar to wild reindeer hunting in Norway. Clients did not want to pay to shoot hinds or calves. The stalker would do that in the winter after the hunting season.

Scottish hunting estates have mainly focused on open landscapes with deer and grouse. Organizations and private individuals have recently bought large estates to restore Caledonian pine forests and other original nature. For example, the British Ornithological Association (RSPB) bought the Abernethy estate with the main goal of preserving the capercaillie population there. Such purchases are common in Scotland; however, we are not aware of similar purchases here in Norway.

The hunting culture in Scotland is very different from our Nordic hunting culture. Many Norwegians hunt in Scotland, often through hunting methods that we do not find particularly expensive. The biggest difference is cultural; in Scotland, hunting is for professional gamekeepers—and for the upper class—whereas hunting in Norway is for everyone.

USA—WILDLIFE IS A PUBLIC RESOURCE

The North American Model of Wildlife Conservation (USA and Canada) is characterized by seven overarching principles (Geist & Organ, 2004; Organ et al., 2012b) and has much in common with the Scandinavian model (Brainerd & Kaltenborn, 2010), but especially the first two principles are different:

1. **The state manages wildlife on behalf of the people (Public Trust Model, Organ & Mahoney 2007):** The people own the wildlife which is managed in trust by the government for public benefit (Peterson et al., 2016). While landowners cannot own either living or dead wildlife, they can restrict access and thereby hunting on their property. This model is known as the *Res communis* model—wildlife is a community property owned by everyone. This differs from the Norwegian model, *Res nullius*, which implies that no one owns wildlife, although landowners have exclusive rights to wildlife felled on their property.
2. **It is illegal to sell game meat and wildlife parts:** Commercial hunting brought many species close to extinction. This was stopped by making it illegal to sell or trade game meat and wildlife parts. The exception strictly regulated fur trapping where fur can be sold on the open market. In Norway, however, game meat and parts can be sold on the open market, which is an incentive for landowners who can earn money from hunting on their properties.
3. **Access to wildlife resources is regulated by law:** As in Norway, access to wildlife is regulated by law. In the USA, The Endangered Species Act provides very strict protection for endangered and vulnerable species. For example, the logging of the last remnants of old-growth forest in the Pacific Northwest was halted to protect the Northern spotted owl (*Strix occidentalis caurina*), an act which led to the loss of between 16,000 and 32,000 jobs (Ferris & Frank, 2021). Democratic processes establish laws and regulations that ensure equal access to wildlife for all in a given state, but non-residents from other US states or countries can also purchase hunting licenses, usually at higher prices. Landowners can earn money by leasing access to their land and selling additional services such as accommodation and guiding. The states can pay landowners to allow hunters access in some cases. On

publicly owned land, access is available to everyone. Hunting is regulated by seasons and quotas and in some cases limited through permit allocations where necessary.

4. **Wildlife can only be harvested for legitimate reasons:** People cannot kill animals for no reason or just for fun. Game must be used, and it is a grave and criminal sin to kill an animal and leave it to waste unrecovered. Meat and/or the hide must be recovered and utilized. In Norway, this is a challenge that journalist Ola Halvorsen (2021) has investigated. Crows take grouse eggs and are huntable, but few eat or use crows. He also shows that it is unlikely that hunting reduces the crow population. However, it must be interpreted from Norwegian laws and regulations that killing crows to prevent predation on eggs must be considered a legitimate reason.
5. **Wildlife is an international resource:** Wildlife species do not recognize national borders, and proper and effective management of species populations must occur through international agreements and cooperation between responsible institutions. Examples include migratory waterfowl species (Anatidae) and barren-ground caribou (*Rangifer tarandus granti*) populations with migratory ranges in Alaska and adjacent Canadian territories. Similarly, Norway participates in the collaborative management and monitoring of international, migratory wildlife such as waterfowl.
6. **Wildlife management is based on science:** Data from monitoring and research form the basis for management and the choice of measures. Wildlife agencies in the USA have large budgets and professional wildlife biologists who monitor and conduct research on wildlife populations and study public attitudes in order to inform and assess management strategies and actions. Similarly, wildlife management in Norway is reliant to varying degrees on scientific monitoring and research.
7. **Hunting has a democratic foundation:** As in Norway, it is important that the public has access to hunting to ensure the future of wildlife and hunting.

Hunters that hunt waterfowl must purchase a Federal Duck Stamp[1] with 98% of the proceeds going to the Migratory Bird Conservation Fund which finances wetland conservation through land purchases. Hunters also contribute to the individual state's wildlife management fund by paying 1) hunter fees, 2) permits for specific species and 3) fees to participate in the lottery for permits on particularly attractive species and populations with limited hunting access.

1 https://www.fws.gov/service/duck-stamps

In the USA, the Wildlife Restoration Act (Pittman-Robertson PR) of 1937[2] mandated an 11% excise tax on the sale of weapons and ammunition that is managed by the US Fish and Wildlife Service (USFWS), the country's overarching wildlife management agency. Funds from this program are known as "Pittman-Robertson" or PR funds, named after those members of Congress who originally proposed the law. Not only hunters but everyone who buys weapons and ammunition in the USA must pay the tax, which has provided an enormous contribution to the individual state budgets for wildlife management uninterrupted for over 80 years, especially in recent years with a dramatic increase in the sale of weapons and ammunition due to political instability. Canada does not have such a source of revenue, and as a result, has comparatively much less money dedicated to wildlife management and research.

The USFWS distributes the funds to the states in grants based on both population size and land area of the individual states. There is a 75:25 match of funds, with the USFWS providing 75% and the state 25%. The funds allocated to wildlife management and research are much larger in the USA than in Norway. For example, the overarching wildlife budget for the Alaska Department of Fish and Game, Division of Wildlife Conservation in 2019, when author Brainerd was responsible for several research programs, was approximately 530 million NOK. Thus, the wildlife budget in Alaska was over five times larger than the Norwegian Wildlife Fund, which spent 93 million NOK in the same year. Alaska's population is only 700,000 residents, but with a land area about five times larger than Norway's.

Alaska stands out from the other American states in many ways, and we emphasize that although the overarching Public Trust model applies to all states (with some exceptions such as Texas, which has a more European-style landowner-based system), the models and conditions vary widely between states. It is easier to compare Norway with individual states than with the country as a whole. The proportion of the population that hunts also varies greatly between states. In California, Hawaii and Rhode Island, 0.7% hunt, while in South Dakota, 24.1% of the population are hunters (Drillinger, 2023).

The North American model has been a great success, promoting public interest in wildlife and contributing significantly to relatively stable wildlife populations managed in a scientific and sustainable manner (see Geist et al., 2001; Pack et al., 2013). The funding model has generated billions of dollars annually for wildlife research, management and local economies in the USA. In Canada, revenues at the provincial level come only from hunting permit sales, while the federal Canadian Wildlife Service receives most of its funding from the regular national

2 https://www.fws.gov/program/wildlife-restoration

budget (Organ et al., 2012b). When author Brainerd traveled as an Alaskan participant at an international caribou conference in the Yukon Territory in Canada, he clearly saw that Canadian caribou research and management was comparatively limited due to less funding compared to Alaska. Although high-quality research has been conducted in Canada (Bergerud et al., 2008) it has not been at the same scale and intensity as in Alaska in recent years. The Canadian Wildlife Service was gutted in the early 1980s when it was dramatically reduced in size with many biologists losing their jobs due to economic conditions. Canadian wildlife management and research could benefit from a model similar to the US PR program, something Brainerd has heard his Canadian colleagues lament about. So in many ways, the North American model, first presented by Canadian authors Valerius Geist and Shane Mahoney (Geist et al., 2001; Mahoney & Geist, 2019), is in many ways an American success story more than a Canadian one since there is vastly more funding for wildlife management and research in the USA.

In the USA, land areas are protected in three different ways at the federal level. These include:

1. National parks
2. Wilderness areas
3. Wildlife refuges

There are a total of 63 national parks in the USA covering approximately 211,000 km^2. National parks are designated for their natural beauty, unique geological features, diverse ecosystems and recreational opportunities. Each park is protected and managed by the National Park Service (NPS)[3]. In addition to national parks, the USA also has various types of preserves and protected areas, including national preserves, national monuments, and national historic sites. Hunting is not allowed in national parks but can be allowed in national preserves. In Alaska, for example, different rules apply to Denali National Park and Preserve. Within the "hard park", no hunting is allowed, whereas some subsistence hunting by local inhabitants is allowed in the adjacent preserve surrounding the park. In Norway, the opposite is generally the case: hunting is allowed in every national park although there is an ongoing debate on whether there should be exceptions to this.

Wilderness areas are protected roadless areas where people can get a feel for the America that the immigrants encountered. People often travel with horses for longer fishing or hunting trips. Motorized travel is usually prohibited in wilderness areas. However, there can be airstrips for people going on trips. Some areas,

3 https://www.nps.gov/index.htm

like Yellowstone National Park and many remote National Parks in Alaska, are both wilderness areas and national parks. Those who want to hike or fish (catch and release in some rivers) must apply well in advance. Only a few people are allowed on the various routes at any given time, as this is stringently regulated through permits. On some routes at certain times, there can be several years of waiting before one is allowed access.

The National Wildlife Refuge System[4] is the system of public lands and waters administered by the USFWS with the aim to conserve America's fish, wildlife, and plants. After its inception in 1903, there are now 568 national wildlife refuges and 38 wetland management districts encompassing about 3,476,200 km^2 of US territory (almost 10 times the land area of Norway at 385,207 km^2). Hunting is an important activity in many of these refuges, which also serves to protect threatened and endangered species and their habitats, often in spectacular settings.

The National Wilderness Preservation System (NWPS)[5] is a network of federally protected wilderness areas comprising over 800 designated areas totaling 449,209 km^2 in the United States. This system was established by the Wilderness Act of 1964. The NWPS aims to preserve the natural conditions of designated areas, ensuring they remain undeveloped and free from human intervention, providing opportunities for solitude, recreation and conservation. Wilderness areas are designated by Congress. Once designated, these areas are managed by various federal agencies including the NPS, the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the USFWS. Hunting is allowed in many designated wilderness areas, but it is subject to specific regulations and guidelines. The rules governing hunting in wilderness areas are designed to ensure that these activities do not interfere with the wilderness character and conservation goals of the area. In general, motorized vehicles are not allowed to access or use these areas.

Protected wildlife in parks generates significant revenue and tourism. In Yellowstone National Park, the world's first national park established in 1872 spanning nearly 9,000 km^2, all wildlife is protected. The wildlife are not very afraid of people. Several roads lead into the park, forming a network shaped like a large figure-eight. Over time, there have been annually 4 million visitors to this remote northwest corner of Wyoming on the Montana and Idaho borders. Most visitors book accommodations at campsites or hotels in advance. They drive along the roads, stay for a night or two, and then continue their

4 https://www.fws.gov/program/national-wildlife-refuge-system

5 https://www.nps.gov/subjects/wilderness/other-federal-wilderness-lands.htm

journey. Hunting wildlife also generates income for guides who take guests hunting outside the parks, often in surrounding wilderness areas in the Greater Yellowstone Ecosystem (GYA). Customers purchase state hunting licenses from the state or through the guides. They often pay for outfitting, accommodations, food and hunting guides.

Texas was part of Mexico before it was taken by the USA, and the hunting rights system has Spanish roots with, for example, landowners having rights to hunting. The law defines exotic species as livestock—which must live behind fences. Many Americans want to go on safari to Africa but find it intimidating or expensive. Instead, they can travel to Texas to hunt kudu (*Tragelaphus strepsiceros*) or eland (*Taurotragus oryx*). The Exotic Wildlife Association claims that many families have managed to survive on their ranches, especially in dry areas, by focusing on exotic animals. To us, hunting exotic species behind fences seems strange, since exotic species are unwanted in Norway and hunting fenced wildlife is illegal. However, it is thought-provoking that the only viable populations of the critically endangered scimitar-horned oryx (*Oryx dammah*), addax (*Addax nasomaculatus*) and dama gazelle (*Gazella dama*) are in Texas. Ranchers ask if it is worse to have non-native nilgai antelopes (*Boselaphus tragocamelus*) than introduced cattle. On publicly owned land in Texas, the public has hunting rights.

The overarching goals for American wildlife management are the protection of wildlife, habitats, and landscapes, and that everyone who wishes to participate in good, traditional hunting regardless of property or income should be able to do so if they have a place to go.

SOUTHERN AFRICA—WILDLIFE AS AN INDUSTRY

In South Africa, Namibia, Zimbabwe and Botswana, various forms of wildlife-based industry have been developed. Management is organized in different ways, but the underlying idea is that if society or individuals make more money from wildlife than from other uses of the land, the wildlife will be preserved. As a wildlife manager in Uganda told author Storaas at a conference in Paris in 2004, "The British protected a quarter of Uganda. The population is increasing rapidly. If we don't earn more from wildlife than from tea or coffee, the protected areas will shrink quickly". In Southern Africa, many have succeeded in making more money from wildlife than from alternative industries. Namibian Minister of Environment and Tourism Pohamba Shifeta stated in a speech in the fall of 2016 that Namibia will heavily invest in wildlife production and wildlife tourism as global warming will make traditional livestock farming more difficult.

In Southern Africa, there are large national parks without hunting, but most wildlife is managed commercially with the aim of economic profit, organized in two fundamentally different ways:

1. Private management behind fences.
2. Game conservancies.

Private management behind fences

In South Africa, during the 1960s, wildlife was considered a pest and a nuisance on agricultural properties (Carruthers, 2008). Wildlife was supposed to be in protected parks, like the famous Kruger Park. If someone wanted to buy a property, the price would be higher if the seller could show that there was no wildlife on the property. In 1964, there were a total of 500,000 large game animals throughout South Africa, in parks and on private land (Du Toit, 2007). In 1991, The Game Theft Act was passed. Landowners then gained property rights over wildlife on fenced land. Many chose to focus on wildlife instead of livestock. They observed that wildlife utilized plants, especially in dry areas, better than livestock did, and managed with less water (Figure 5.1).

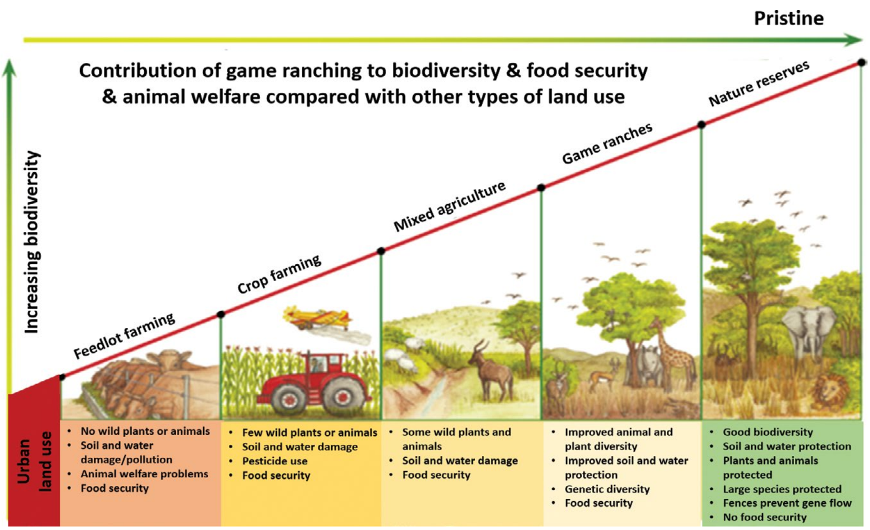

Figure 5.1: Various forms of land use from urban settings to untouched wilderness in South Africa. Adapted from Oberem (2016).

In 2008, landowners lost control over a few endangered species that were placed under public management (Cousins et al., 2010). By 2016, the number of wildlife had increased to 17.5 million, and the goal of the wildlife ranchers' organization was 30 million large game animals by 2021 (Oberem & Oberem, 2016). The increase has occurred on private properties where owners realized they could earn more from wildlife alone or in combination with livestock. Modern Western agriculture thrives on the best South African soil where there is enough water. But in drier areas, different wildlife species exploit their respective food plants far more efficiently with much less use of water (Oberem, 2016).

People can have various opinions about wildlife behind fences. Aldo Leopold, as well as our Norwegian Wildlife Act, defines wildlife as free-ranging animals. But are animals behind fences wild and free-ranging? And is it really hunting if one harvests fenced animals? In hunting, wildlife should have the chance to survive and avoid being harvested. The fenced areas can be small. A lion family in a small area will depend on artificial feeding. The landowner can let a hunter come and harvest one of the lions in the family, preferably the old male lion that was due to be replaced anyway. This is called canned hunting. The wildlife is served as in a tin can; it is just a matter of opening the can and shooting the wildlife inside it. Hunting organizations strongly oppose this form of harvesting, which they do not define as hunting. Tickle and von Essen (2020) argue that there are ethical challenges associated with trophy hunting, that many hunting tourists lower their ethical standards when they pay well for hunting abroad, and it is important that trophy hunters maintain high ethical standards and behave according to the same standards as at home.

A landowner can choose which animals he wants on his fenced property. If the price for albino wildebeest becomes high, he can buy and start breeding albino wildebeest. Others might focus on other rare variants of different species. There is good economics in having impressive animals with large horns on the property. People want to see these animals, and some pay a lot to harvest them as trophies. The price for impressive breeding animals is high. For example, author Storaas noted at a conference in South Africa in 2011 a lot of talk about a cape buffalo (*Syncerus caffer*) bull that was sold for the equivalent of 14 million NOK. In 2015, a sable antelope bull and a kudu bull were sold for 16 and 6 million NOK, respectively (Pitman et al., 2017). The wildlife industry involves large sums of money.

It challenges both the law and our attitudes when non-native species are introduced or when large horned animals are brought in to mate with local variants with smaller horns through designer breeding (Lindsey et al., 2009).

Pitman et al. (2017) show that when very valuable animals are fenced, many landowners become less tolerant of large predators that can kill them or free-ranging elephants that can damage fences. It is thought-provoking that the largest populations of both black and white rhinos occur behind fences in South Africa rather than in other African countries where they roam wild and are protected. These fenced enclosures in South Africa vary from small to very large. Many fenced areas are so large that they contain adequate year-round habitats for entire wildlife communities and are not perceived as fenced. For example, Kruger National Park, which is the largest park encompassing 19,623 km^2, is fenced. For comparison, the former Norwegian county of Sogn og Fjordane was 17,619 km^2 and the former county of Sør-Trøndelag was 18,848 km^2.

The fenced areas can contain livestock and a few wild species that are intensely managed for hunting. At the other end of the spectrum is Kruger National Park, which does not allow hunting. From a wildlife enthusiast's perspective, some wildlife seems better than no wildlife. The best scenario would be large areas with traditional intact migration routes and wildlife communities. There are certification schemes to ensure for tourists and hunters that a property is being operated in an ecologically and socially responsible manner. There is a trend that more and more properties are amalgamating to create larger fenced enclosures with all-natural animal species that can be organized as joint-stock companies with share distribution based on the value of the contributed property.

Wildlife management behind fences can seem challenging. Are fed lions or fenced rhinos really wild animals? Both would kill you if given the chance. But are they then tame? In Norway, we have semi-domesticated reindeer and wild reindeer with the same genetic origin as one species. Wild reindeer have domesticated reindeer genes in varying frequencies. Is the semi-domesticated reindeer a kind of gene bank for wild reindeer, and are fenced black and white rhinos gene banks for free-ranging wild rhinos? Management behind fences is challenging in many ways, but can we overlook the fact that more animal species may survive over time because they provide owners with better economic returns than alternative agriculture? The question might be what realistic alternatives exist to keeping wildlife as property behind fences.

Game conservancies

While it is common to fence wildlife in South Africa and the Southern part of Namibia, unfenced game conservancies are typically used to manage wildlife in Northern Namibia, Zambia, and Zimbabwe. Zimbabwe pioneered locally based game conservancies through the CAMPFIRE program. CAMPFIRE stands for Communal Areas Management Programme for Indigenous Resources. Revenues from African resources have often ended up in secret accounts in Switzerland. In contrast, CAMPFIRE aims to transfer the rights to use wildlife to local communities. As early as the 1980s, wildlife management units were organized to be managed locally with hunting and tourism as products. Through this program, most of the revenues have returned to the local people, where village councils decide what the money should be used for. The idea is that the locals will then think long-term and take care of the wildlife resource. Zimbabwe has since faced very large political challenges. The program has been evaluated in various places and at different times. In some cases, it has worked well. The biggest challenges have been corruption and achieving long-term security for investments. It has been very uncertain for white partners who have often been expelled from the country without warning.

In Zimbabwe, individuals or groups have organized game conservancies within or outside the CAMPFIRE program. Hunting rights owners have formed game conservancies over large contiguous areas with clear boundaries. They have used two main models:

1. **An administration that manages the area:** Revenues are distributed among the owners based on how much land they have or how much they have invested in the project.
2. **A joint administration that only manages wildlife and enforcement:** Each owner gets their hunting quota on their own land.

Ntuli and Muchapondwa (2017) found that game conservancies functioned far better than the CAMPFIRE program. They pointed out that the governing body in CAMPFIRE was weak and it was lucrative for the local population to poach, while game conservancies yielded better returns than CAMPFIRE areas. Ntuli and Muchapondwa (2017) believe CAMPFIRE must learn lessons from the game conservancies.

Rhino horn—worth its weight in gold

The populations of black and white rhinos increased when commercial hunting began in South Africa but started to decline again due to poaching (Figure 5.2, ’t Sas-Rolfes et al., 2022). The horn on the rhino’s nose, made of keratin, can be sold for more than its weight in gold (Biggs et al., 2013). Rubino and Pienaar (2017) cite sources that rhino horn could be sold for between 500,000 and 1,000,000 NOK per kg in 2016 and 2017, while the gold price was below 350,000 NOK per kg. One horn could be worth around 5 million NOK (Rubino & Pienaar, 2017). Poaching peaked in 2014, decreased during the COVID-19 pandemic, but has begun to increase again afterward (Save the Rhino, n.d.). Criminal syndicates organize the trade and recruit and arm local poachers, many of whom are killed in encounters with heavily armed paramilitary guards. Drones are being developed and launched, and surveillance systems are set up to alert when there are people and armed people in the area. Purchasing and staffing surveillance systems are expensive, and guarding is dangerous (Lunstrum, 2014). Nevertheless, poor young men choose to engage in risky but profitable poaching (Lunstrum et al., 2023).

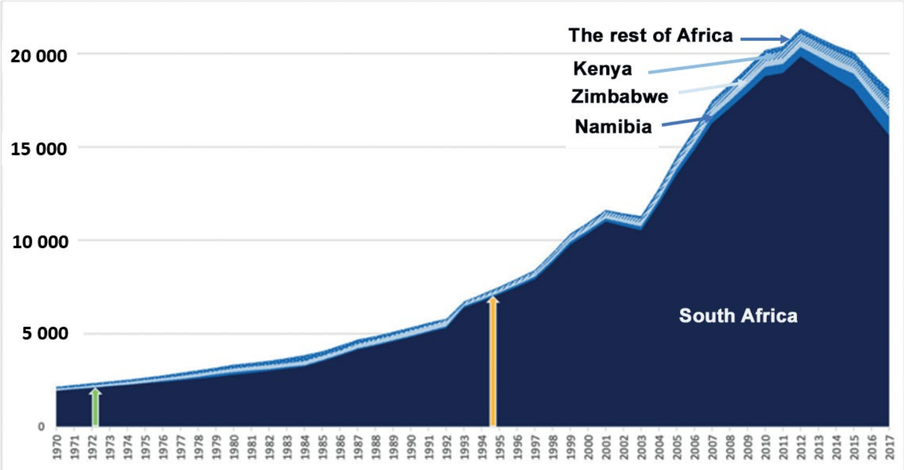

Figure 5.2: The total population of Southern white rhinos distributed by country. The green arrow indicates when commercial rhino hunting began in South Africa, and the yellow arrow indicates when the rules for exporting trophies were simplified. In recent years, populations have declined due to poaching (after ’t Sas-Rolfes et al., 2022).

CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, has decided that rhino horns cannot be sold. Rhino horns can be cut off—and they grow back. The owner can harvest 1 kg of rhino horn, equivalent to over 1 kg of gold, annually from an adult animal. Without the possibility of selling this “gold,” it becomes expensive to take care of the animals. Rhino owners argue for opening up sales; many say it is far more profitable and safer to let the poachers take the rhinos—and themselves rather than focus on other species (Rubino & Pienaar, 2017). Taylor et al. (2017) pointed out that prohibition and punishment do not seem to prevent the unsustainable poaching of rhinos, as many poachers do not have alternative income-generating opportunities. Taylor et al. (2017) calculated that in South Africa alone, between 5 and 13 tons of rhino horn could be sustainably obtained annually from horn cutting, naturally dead animals, trophy hunting and stockpiles. If trade were legal, rhino sales could generate between 2.5 and 6.5 billion NOK. This would place enormous value on rhinos for owners and managers. Legal trade would be a strong incentive for sustainable use and conservation.

’t Sas-Rolfes et al. (2022) present a model for how public and private areas can collaborate to take care of rhinos by generating income through both grants, mass tourism and hunting (Figure 5.3). When rhinos have habitats and are protected from poaching, the population will increase. They can migrate into areas with limited hunting that remove some individuals. Others can be relocated to private areas for hunting. In private areas, profitability can become so good that owners prefer wildlife and rhinos over alternative income sources. Thus, the total area for rhinos and the number of rhinos can increase, while ensuring economic security. The rhino model could also be used for other large and endangered species like tigers and elephants. The challenge is to have good enough control over management. The model requires good organization and consistent anti-corruption efforts.

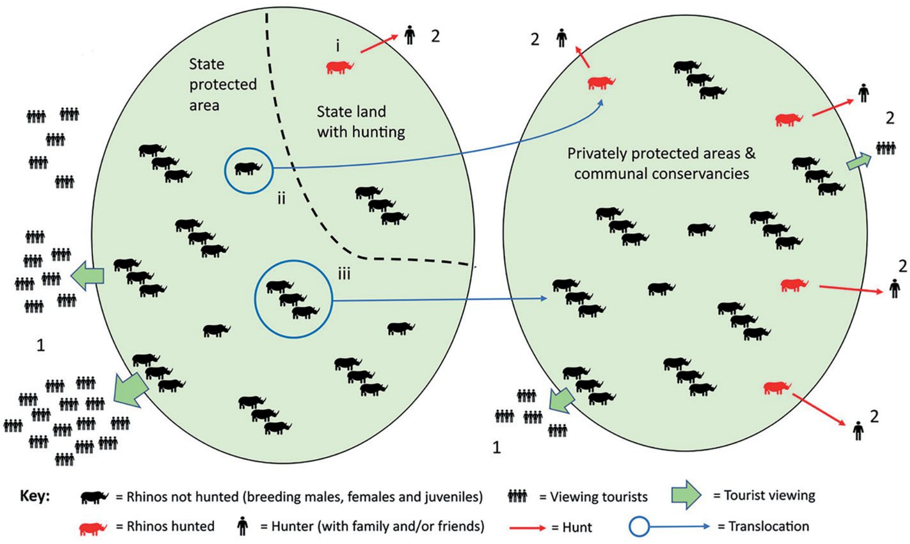

Figure 5.3: A model for funding rhino conservation through collaboration between private and public landowners. Income comes from many non-hunting tourists (1) and few legal hunting tourists (2). Rhinos come to hunting areas and private land through (i) migration, (ii) capture and relocation of surplus males, and (iii) relocation of family groups. After ’t Sas-Rolfes et al. (2022).

In national parks in Africa, large game populations have been more than halved. However, there are significant regional differences; in Southern Africa, large game populations have fared well (Craigie et al., 2010). We can speculate whether the reason is that wildlife is an economic benefit for landowners and the local population. Parker et al. (2020) point out that a ban on trophy hunting can have many negative impacts on the conservation of biodiversity, the national economy and the standard of living for farmers and employees. Batavia et al. (2019) write that if the preservation of wildlife and nature depends on trophy hunting, it must be seen as a tragedy with pangs of conscience and sorrow. At the same time, it seems to work. In 2023, wildlife farm owners started the online magazine *Rewilding Southern Africa*[6], which aims to promote good ecosystem management. The hallmark of wildlife management in Southern Africa is large national parks and commercial operation of spectacular large game and wildlife communities outside and behind fences.

THE NETHERLANDS—PEST CONTROL AND LIMITED HUNTING

The Netherlands covers 41,526 km², barely 11% of Norway's land area, with three times as many inhabitants. Initially, all wildlife is protected except for black rats (*Rattus rattus*), brown rats (*Rattus norvegicus*) and house mice (*Mus musculus*). Hunting is permitted for small game species such as European hare (*Lepus europaeus*), pheasant (*Phasianus colchicus*), mallard (*Anas platyrhynchos*), wood pigeon (*Columba palumbus*), rabbit and grey partridge (*Perdix perdix*). Although partridges can legally be hunted, the season is currently closed due to low populations struggling in an intensively farmed landscape. In the Netherlands, there are around 1,800 red deer, 60,000 roe deer, 1,150 fallow deer, 50–100 Chinese muntjacs (*Muntiacus reevesi*), 300 mouflons, 2,300 wild boar (Wieren & Bruinderink, 2010) and 18 million people. With a population density[7] of 426 people per km², and with so many people and so little wildlife, it's not surprising that only 27,000 (0.15%) of the population hunt[8]. The Flora and Fauna Act of 2002 categorizes hunting into three types: hunting, management and pest control. For ungulates, culling is called management, and for geese and crows, it is pest control. The landowners have hunting rights, which they can lease. To obtain a hunting license, the hunter must be 18 years old, have passed a hunting exam, have special hunting insurance and prove they have a hunting area.

Red deer, roe deer, wild boar and fallow deer are protected and can only be culled for the following reasons:

- Public health and safety.
- Accident prevention at airports.
- To prevent damage to crops, livestock, forests, fisheries and water.
- Other specified reasons.

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6 https://globalrewilding.earth/rewilding-southern-africa-magazine-nature-and-storytelling/

7 https://www.macrotrends.net/global-metrics/countries/NLD/netherlands/population-density

8 https://www.jagersvereniging.nl/vereniging/english/

Culling (not "hunting") can only occur during specified periods. The damage must be extensive, and other possible measures should be tried first. As a result, ungulate populations in many areas are unregulated. Many conservation organizations advocate for nature to develop without human intervention, which leads to dense populations. However, the muntjac is blacklisted as an invasive species, and efforts are made to eradicate it.

Before our ancestors eradicated the aurochs (*Bos primigenius*) and the tarpan (*Equus ferus ferus*) and nearly exterminated the European bison (*Bison bonasus*), these species grazed in the Netherlands. There have been attempts to breed back to wild horses and aurochs, and Konik horses (*Equus caballos*; May-Davis et al., 2018) and Heck cattle (*Bos taurus*; Katz 2023) are considered most similar to their wild ancestors. In two areas, Veluwezoom National Park (110 km^2) and the fenced island area Oostvaardersplassen (52 km^2), Heck cattle and Konik horses graze freely in what is intended to be a free and functioning ecosystem. However, since the areas are small and without large predators, and the animals are not truly wild, they are not allowed to suffer from starvation or disease. Animals that are not in good health are therefore culled (Schwartz, 2019). To prevent increasing geese populations from destroying crops, they are captured during molting, when they cannot fly, and euthanized with gas (van Eerbeek, 2013).

The Netherlands is a fertile small country with many people who want natural nature in dysfunctional, small areas. Culling of wild animals must nevertheless sometimes occur, but hunting for recreation is foreign to most Dutch people.

SWITZERLAND—EQUAL RIGHTS FOR CANTON RESIDENTS

Switzerland is a federation of free cantons or counties. The Swiss hunting law "*Bundesgesetz über die Jagd und den Schutz wildlebender Säugetiere und Vögel*" (Swiss Confederation, 1986) provides overarching principles and rules, and each canton specifies hunting as the residents of the canton wish. The hunting rights belong to the people of the canton. The people can, as in the canton of Geneva, prohibit all hunting. The hunt is managed by the authorities in each canton and is for the residents of the canton. However, residents can decide that permits to hunt some trophy animals should be auctioned off. The trophy fee for an auctioned ibex (*Capra ibex*) with 100 cm horns in 2020 was around 670,000 NOK (Hunt in Europe, 2021). This money goes to wildlife management in the canton.

The cantons in the north have divided themselves into hunting fields. Hunting in the hunting fields is leased out for longer periods to groups of hunters from the canton. In the south, all residents have equal rights in the lottery for hunting permits. Some permits are given to everyone who applies. Permits for species like ibex are rare. It is a free lottery, but to get a big buck, the hunter must be older. If they are lucky, the hunter may first get a permit for a small buck. After the hunter is older, they may be lucky to get a permit for a big buck.

It is enshrined in the Swiss constitution that citizens can go wherever they want in the countryside. This right is practiced slightly differently in various cantons with some areas being protected for nature conservation reasons. The hunting rights and right of trespass belong to the people of the canton. The hunting regulations reflect that the Swiss are a people of equals, where everyone should have the same rights to walk and hunt in their canton.

SUMMARY OF RULES AND RIGHTS

In Kenya, all wildlife is protected, and it works well in the most visited national parks. But when there is little to earn from wildlife and much to earn from poaching, it has led to wildlife populations declining significantly, especially outside tourist areas. Challenges include rapidly increasing population, poverty and corruption. In Southern Africa, with economically profitable and sustainable wildlife populations behind fences, wildlife populations have increased significantly (Figure 5.4).

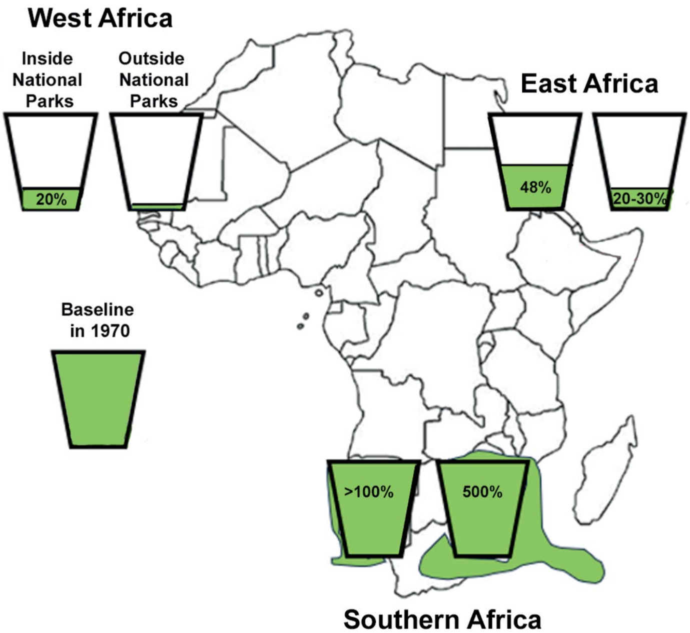

Figure 5.4: How wildlife populations have changed from 1970 to 2010 in some countries in West Africa, East Africa and Southern Africa. The jars show how much wildlife there was in 1970, while the blue liquid symbolizes the amount in 2010. Adapted from a PowerPoint figure by Mike Knight and Richard Emslie based on Craigie et al. (2010).

In Scotland, hunting management is a large industry concentrated on grouse and deer on private properties. Red grouse shoots and red deer hunts are very expensive and reserved for wealthy hunters and their guests. Several estates have been purchased by private individuals and organizations for conservation purposes. In the USA, hunting rights are equal for all residents of the state. Wildlife management has many resources for wildlife research and management, especially due to the excise tax on weapons and ammunition. Landowners can prevent trespassing on their properties. In practice, residents can hunt on publicly owned land, and landowners can charge for people to trespass on their land. Participation in hunting varies greatly between states.

The Netherlands is cultivated and densely populated. Hunting is foreign to most people, although they want nature to return to its natural state in areas that are too small to be ecologically functional. The Swiss system ensures equal access to hunting for all residents of the canton.

Table 5.1: Property conditions, rights related to wildlife and wilderness, and percentage of hunters in the discussed countries.

Country	Who Owns Wildlife?	Hunting Rights	Sale of Game Meat	Right of Trespass	Percentage of Hunters
Norway	None	Landowner	Yes	Yes	9.4
Kenya	State	None	No		0
Scotland	None	Landowner	Yes	Yes (new right)	1.2
USA	State	The public	No	No	5
South Africa	Landowner	Landowner	Yes	Not on fenced land	–
The Netherlands	All	Landowner			0.16
Switzerland	Switzerland	People in the canton	Yes	Yes	0.35

DIFFERENT EUROPEAN HUNTING CULTURES

In Europe, the proportion of hunters in each country varies between 1 per 618 (0.16%) in the Netherlands to 1 in 12 (8.33%) in Ireland[9]. The Federation of Associations for Hunting and Conservation of the EU (FACE)[10] and Pinet (1995)[11] described four different hunting cultures in Europe:

9 https://www.face.eu/sites/default/files/attachments/data_hunters-region_sept_2010.pdf
10 https://www.face.eu/hunting-methods-culture/
11 http://psymoje.pl/wp-content/uploads/2011/07/lowiectwo-w-Europie-podsumowanie.pdf

1. **Nordic hunting tradition:** An egalitarian tradition where people from all social classes hunt primarily for meat and recreation. Very high ethical standards including mandatory shooting tests and tracking wounded big game with certified dogs. A relatively high proportion of the population are hunters compared to most other European countries.
2. **Anglo-Saxon hunting culture:** Intensive game management, upper-class hunting, dense game populations, game keeping, importance of trophies, falconry.
3. **Germanic hunting culture:** Difficult hunting exam, affluent groups lease hunting rights and are responsible for game and game damage in the area, rules, trophy hunting, highly urbanized. Formalities are important, including ceremonies, uniforms and horn music.
4. **Mediterranean (and Irish) hunting tradition:** Hunting is very popular in rural areas, many species are hunted, live-trapping of birds in some areas, falconry, use of dogs, small game hunting is particularly popular.

AUTHORS' REFLECTIONS

Raised in Hardanger, author Storaas was sure that the Norwegian wildlife management system was the only right one, as American author Brainerd was just as sure that the American system was best. An important realization is that no natural law says we should hunt wild animals—or protect them. No natural law dictates who should have the right to roam or to hunt. It seems that rules for freedom to roam, hunt and trap are set based on traditions, customs and past and present power dynamics.

It is clear that human use of nature must be regulated for valuable wildlife species to survive. In well-organized countries with a functioning legal system and national audit, as well as a free press, wildlife can be protected through both hunting and hunting bans, landowner rights, or general hunting rights. In unsuccessful countries without a well-functioning central administration and national audit, it is difficult regardless of the management system. Whether wild animals are truly wild when they are behind fences can be debated. Nevertheless, it is striking how the economy of wildlife use has increased the number of large game animals in Southern Africa, while the number of large game animals in protected Kenya has decreased. It is easy to get the impression that allowing strictly controlled sales of ivory and rhino horns could benefit elephant and rhino populations. It would be interesting to see an overview of how the different legal systems around the world affect people and wildlife.

Brainerd, S. M. & Storaas, T. (2025).
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Scandinavian University Press.
https://doi.org/10.18261/9788215075174-25-06

6. Ecological concepts and factors that managers can influence

In this chapter, we will discuss ecological concepts and how wildlife managers can influence wildlife populations to achieve management goals. Wildlife management requires ecological knowledge. Krebs (1994) defines ecology as "the scientific study of interactions in nature that determine the number and distribution of organisms." Understanding which factors determine the number and distribution of a wildlife species, and which factors can be manipulated to achieve various goals, is not easy. "Everything is connected to everything", said former Prime Minister Gro Harlem Brundtland. This applies not only to politics but also significantly to ecology. Thorough studies of ecosystems, such as the over 30-year-long work by Charles Krebs and colleagues in pristine coniferous forests in Kluane in Yukon, Canada, show an extensive food web with plants, herbivores, predators, and humans with a complex network of relationships between different species, where some connections are stronger than others (Boonstra et al., 2018). Norwegian researchers have, through extensive and demanding efforts, succeeded in determining how important factors such as hunting, small rodents, reindeer carcasses, and red foxes influence grouse densities in a tundra environment on the Varanger Peninsula (Henden et al., 2021).

The Norwegian Red List for Species 2021 (Artsdatabanken, 2021a) has assessed over 23,000 species and classified 2,752 of these as threatened. Most species are threatened by loss of area, habitat, or habitat where they can survive and reproduce. We will therefore first discuss what habitat is and see how wildlife managers can alter it to benefit wildlife, preferably by influencing the most limiting factors. We discuss the relationship between production and carrying capacity. Finally, we will discuss some limiting factors such as predation and disease.

HABITAT

A habitat is an area with a combination of resources (such as food, shelter, water) and conditions (such as temperature, precipitation, predators, competitors) that allow individuals of a specific species to survive and reproduce (Darracq & Tandy, 2019). Habitat is linked to a species, and wildlife needs access to good habitats throughout the year, preferably in different areas, for migratory birds even on different continents. The term “habitat type” has often been mistakenly used for vegetation communities at specific succession stages (Hall et al., 1997). Such elements with specific vegetation and wildlife can be called a biotope and can be part of a species’ habitat. Many species utilize their own habitat in the same area, living in communities in their own niches. When a species is threatened, it is usually because its habitat becomes too small or degraded. Habitat can become fragmented into small patches due to the physical destruction by logging or development, or the connectivity between seasonal habitats can be hindered by various forms of destruction through human activities. Forestry practices that degrade or destroy important species’ habitats may also favor predators that feed on habitat specialist species, thus compounding negative effects. Likewise, other forms of human disturbance, such as unregulated use of an area for recreation in critical, limited habitat during particularly sensitive periods, can degrade the utility of existing habitat patches for some species.

Ecologists talk about landscapes of fear as a trade-off between avoiding predators and accessing food at a spatial scale (Brown et al., 1999). In the 1970s, students at our Evenstad campus reported that crows flying north or south along the valley flew in a large arc around the school. The crows knew that if they came near the school, they would be shot at since many of the students at that time were avid hunters. Bleicher (2017) provides a nice overview of the concept of “landscapes of fear”. In Scandinavia, researchers have studied how fear of humans has affected the food intake of bears (Støen et al., 2015; Lodberg-Holm et al., 2019) and how wild reindeer fear humans and concentrate in areas with little human activity (Gundersen et al., 2021). But protected wildlife in national parks can also learn to use people as shields against predators (Berger, 2007).

The quality of habitats varies. For example, Kvasnes et al. (2014) found over time a large difference in the density of grouse pairs on different hunting grounds, but the production of chicks per pair was independent of the density of pairs. Willow ptarmigan that seemed to live in poor habitats with few pairs could produce more chicks than those in what seemed like good habitats with many pairs. This corresponds with earlier work showing that both density and reproduction must be measured to know what is the best habitat (Van Horne, 1983). In the best ptarmigan habitat, there were both many pairs and good chick production. Areas with a birth surplus are called source areas from where individuals may disperse while areas with a birth deficit are called sink areas and may depend on immigration from source areas.

Liebig's law of the minimum implies that population growth is dictated not by total resources available, but by the scarcest resource. For a given species, there may be several potential limiting factors, such as availability of food, shelter, weather or climate conditions, predation or human-caused mortality. What factor is the critical limiting factor, or minimum factor, may vary from place to place. Thermal shelter is critical for American martens (*Martes americana*) due to their body shape and poorly insulative fur, and they depend upon dead and decaying wood to provide thermal shelter in old-growth forests that is not available in forests regenerating after clear-cutting (Buskirk et al., 1989). In Norway, the related pine marten seems to thrive in forests that lack such dead wood, probably because of the omnipresence of underground shelter in the form of an abundance of boulder fields in rugged terrain (Brainerd et al., 1994; Angoh et al., 2023). Birds that nest in cavities must locate in suitable places before they can reproduce (see Wiebe, 2011). Reindeer populations need sufficient winter forage, otherwise populations may crash (e.g., Klein, 1968). Islands that were once prime nesting habitats have been cleared of seabird nests and chicks since the arrival of mink (Banks et al., 2008). Isolated resting places, cavities, winter grazing and predator-free nesting sites can be limiting factors that determine how large populations can become. If the manager knows what the critical minimum factor is, they may be able to implement measures to manipulate a population according to their goals.

The challenge with small, isolated patches of habitat is that few individuals can live there and small populations are at risk of extinction due to random variation or inbreeding. The Arctic fox population in Norway was very small and fragmented with a high chance of extinction due to stochasticity (Linnell et al., 1999). In the highly inbred Scandinavian wolf population, wolf litter size was negatively correlated with the degree of inbreeding (Liberg et al., 2005). The best example of the misery of inbreeding may come from humans. The Habsburg family ruled Spain for five generations, they interbred within the family, and it ended with the last inbred king, Charles II, being almost deaf, blind, paralyzed, toothless, and infertile when he died in 1700 (Haraldsen, 2009). Inbreeding is good for neither people nor animals.

Immigrants and reintroductions can alleviate inbreeding in small, isolated habitats. The small wolf population on Isle Royale in Lake Superior in the USA seems to have been saved several times by immigrants, before the wolves became so inbred that they were no longer fertile (Robinson et al., 2019). It seems that small populations that have long been isolated have either gone extinct or managed to rid themselves of genes that become harmful when homozygous. Large populations have more harmful genes that do not express themselves because individuals rarely contain two copies of the same harmful gene. If an individual from a large population is introduced to an isolated, inbred population, with the intention of augmenting genetic diversity, it may initially have this effect. However, since the introduced individual may carry more harmful recessive mutations than were originally present in the isolated population, these genes may become homozygous and actually exacerbate inbreeding depression (Robinson et al., 2019). This is thought-provoking because it seems counterintuitive. If a small, isolated capercaillie population in Germany is supplemented with individuals from a large Norwegian population, it may be negative in the long term. For it to work well, new birds must probably be continuously supplied over time. In Norway, the arctic fox population recovery program, which emphasizes captive breeding and reintroduction of individuals to augment genetic variation and connectivity, has thus far been successful (Hemphill et al., 2020). Hedrick et al. (2019) assess how small populations can be preserved through the introduction of new genes. It is very clear that the best measure is to address the causes of the population being small, make the habitat larger, or manipulate the limiting factors. The wolf population on Isle Royale went extinct when there was no longer stable ice allowing new wolves to immigrate to the island from the mainland population (Robinson et al., 2019).

Attempting to identify limiting factors and conserving or restoring adequate habitat are crucial tasks in wildlife management. Donaldson et al. (2017) state that the traditional approach to conservation is to promote larger and more protected areas, ensure better connectivity between areas, and improve habitat quality. They review the literature and show that today we also need to consider global warming and the immigration of harmful exotic species. They point to phenomena that we can illustrate from Norwegian wild reindeer: if the wild reindeer populations are interconnected, chronic wasting disease can spread more easily to all wild reindeer. We, the authors, still believe that habitat quality and larger patches of habitat should be prioritized and that it is usually beneficial to have connectivity between habitats.

POPULATIONS

A population is a group of the same species living in the same area, where interbreeding within the group is more likely than with individuals from outside (Mayr, 1976). The concept of a metapopulation was developed by imagining populations on islands with water between them, meaning a collection of nearby populations with occasional exchange of individuals (Levins, 1969). A research group has studied greater sage grouse (*Centrocercus urophasianus*) in the USA on nearly 6,000 leks using almost 3,000 radio-tagged birds from 2006 to 2020. They developed a method to define biologically relevant subpopulations that are connected at various levels, from being cohesive mating groups to isolated populations, and looked at the genetic consequences of this (O'Donnell et al., 2022; Zimmerman et al., 2023). It requires extensive research, at great cost, to define populations in such a manner, something which is impractical for most situations. Managers must be pragmatic and try to manage populations as best they can in light of this. Pragmatically, managers often consider a population as being defined as a collection of individuals of the same species in a specific geographic area, according to Leopold (2018). In practice, population and management areas are usually delineated by property boundaries, municipal boundaries, county boundaries, or national borders that may have nothing to do with the actual boundaries of a given population for some species and areas.

The Norwegian Cervid Regulation requires population management plans for moose and red deer. It can be easy or difficult to delineate populations. A wild reindeer population is usually bounded from other populations by barriers that are rarely crossed. However, herds can cross boundaries between defined wild reindeer areas. In some areas, such as Rondane, human activity has more or less divided the population into subpopulations in recent years. Each now has its own culling plan, although these areas occasionally exchange individuals. In Alaska, author Brainerd and colleagues defined caribou populations by their calving grounds (e.g., Valkenburg, 1998; Valkenburg et al., 2016), knowing that there is some interchange between herds based on satellite telemetry data (Pritchard et al., 2020) and genetics (Mager et al., 2014). It is relatively easy to define populations of species like caribou with defined calving grounds and migratory routes, or populations inhabiting isolated mountain areas or islands (e.g., moose: Sæther et al., 2007), but it is more difficult for other species, such as moose or red deer, that occur over large expanses of mainland Norway that allows interchange through migration and dispersal where significant landscape barriers are lacking.

Moose, of course, do not perceive administrative boundaries. In some areas, moose are stationary. Other moose migrate between summer areas with high precipitation and winter areas with little snow (Andersen & Sæther, 1996). Different moose in one summer area may migrate to various winter areas, and moose in one winter area may migrate to different summer areas. Once adult moose have established themselves, they usually use the landscape as they did the previous year. A large portion of moose calves can disperse from 10 to several kilometers away from their mother's home range (Rolandsen et al., 2010). There are rarely clear boundaries between moose populations in mainland Norway. Managers must do their best to delineate boundaries such that most moose are in the management area most of the year. It is also important not to make the management area larger than what those with hunting rights perceive to be a shared population.

It is also difficult to delineate willow ptarmigan populations. Hörnell-Willebrand et al. (2014) calculated that to include the nesting area of half of the young hens born in the area, one needs an area of 400–500 km². Most boundaries between management areas, however, follow property boundaries, and these are usually much smaller than this. Since juvenile males usually disperse short distances and young hens disperse further and settle where they find a male, we can perhaps assume that about as many hens migrate in as out. In addition, willow ptarmigan often migrate far from nesting sites and mix with others in winter, so winter hunting can be on mixed breeding populations (Frye et al., 2022).

It is also challenging to draw boundaries between capercaillie populations. We captured two hens and six males on two neighboring leks at Evenstad and placed GPS transmitters on them. If we draw a circle that includes the furthest distances males and hens were from the leks, the male circle will cover 1,661 km² and the hen circle 2,289 km². These areas are the potential areas the birds could use if they flew like the longest-traveling radio-tagged birds. If the leks are spaced just over 2 km apart (Wegge & Rolstad, 1986) and we exclude farmland and mountains, the area the two hens could potentially use could cover nearly 500 leks. It is thus quite difficult to delineate populations of small game species like capercaillie or willow ptarmigan for management purposes.

When researchers place GPS transmitters on animals, we see that many animals usually use much larger areas than most people previously believed. Measures in areas that are large for us but small for wildlife will therefore often have less impact than expected. At the same time, we often see that a large portion of the adult population stays in the same small area throughout the year. The leader of the Norwegian Red Deer Center, Johan Trygve Solheim, told the authors that they have succeeded in increasing the average age of deer and the proportion of bucks per doe through targeted culling on the 11 km² island of Svanøy. The distance to the mainland from Svanøy is relatively short, such that there is free exchange between mainland and island populations. This may indicate that we perhaps place too much emphasis on the migrating part of the population and forget that what we do locally also matters. Usually, the manager does not know exactly how large an area the population uses, where boundaries between populations lie, or how many animals are truly local. Managers must do their best, both in managing the part of the population within the areas they manage and, perhaps more importantly, by creating generous and trusting cooperation with neighbors within their management unit(s).

CARRYING CAPACITY—FAST AND SLOW SPECIES

When a population establishes itself in a habitat and grows without limitation, it will increase rapidly until there is competition for resources, the death rate increases, the birth rate decreases, and the population growth levels off, reaching carrying capacity. Fast species with high maximum growth rates, r-selected species, quickly reach carrying capacity. Slow species with low maximum growth rates, K-selected species, take longer to reach carrying capacity in the habitat (Figure 6.1). This is illustrated by the simple and theoretical logistic population model, $dN/dt = \text{rmax}\, N\,(1 - N/K)$. N is the population size, and K is the carrying capacity. dN/dt is the change in individuals (dN) in the population over a short time interval (dt). The maximum growth rate, *rmax*, is how much the population is capable of growing per individual during the interval under optimal conditions. Maximum growth rate, rmax, characterizes the different species. When population N reaches carrying capacity K, rN is multiplied by 0, and growth stops (Figure 6.2).

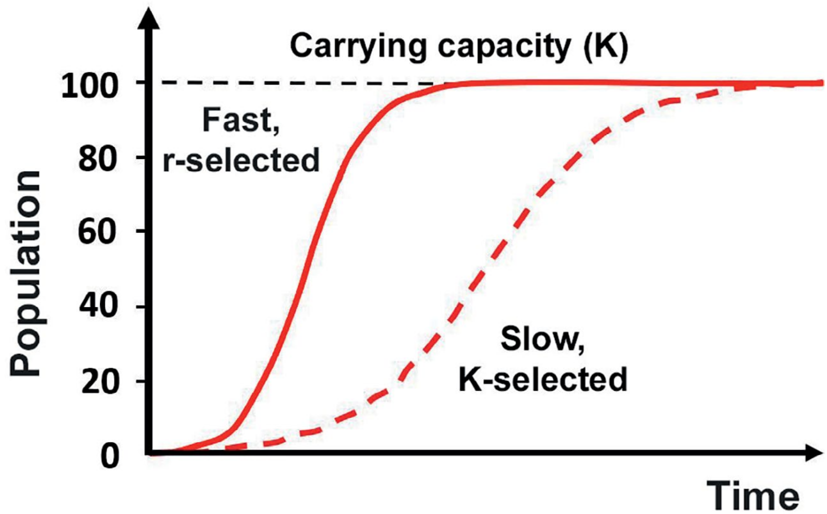

Figure 6.1: According to the logistic model, individuals of a species that enter suitable habitat without predators reproduce, and the population grows before leveling off at the carrying capacity level (K)[1]. Fast r-selected species will grow faster than slower K-selected species. Both r- and K-selected species can exceed K and crash. However, the relative amplitude and periodicity for r-selected species will be more extreme than for K-selected species.

1 https://artofsmart.com.au/biology/qce-biology-external-assessment/

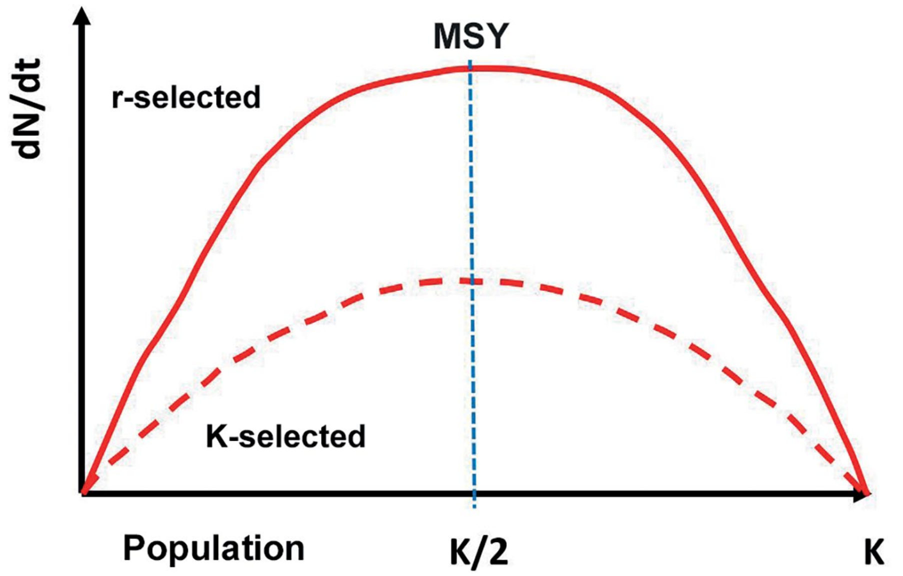

Figure 6.2: As a population increases, production within the population also increases, but competition for resources causes production per individual to decrease, and population production levels off to provide maximum sustainable yield (MSY). When the population increases even further, production per individual decreases so much that production within the population approaches zero when the population size reaches carrying capacity (K). Wildlife managers can influence both production and carrying capacity through measures. dN/dt is how much the population changes during a short time interval.

Chapman and Byron (2018) show that "carrying capacity" has been a widely used term over time with somewhat different and unclear meanings and is used in many contexts. If the population reaches carrying capacity K in the model, the population and environment will become degraded. A well-known example is the protection and eradication of predators that led to the growth and crash of the aspen (*Populus tremuloides*) and the mule deer (*Odocoileus hemionus*) population on the Kaibab Plateau in Arizona (Binkley et al., 2006). There are similar examples where reindeer populations peaked and crashed after overpopulation and subsequent forage depletion: wild reindeer in Snøhetta (Jordhøy, 2001) and introduced reindeer on St. Matthew Island in Alaska (Klein, 1968). In Alaska, Boertje et al. (2007) documented the effects of population density on moose nutritional condition and reproduction. Chapman and Byron (2018) argue that authors should be careful to define what they mean by "carrying capacity". They write that production carrying capacity can be useful in some contexts for the maximum biomass of a wildlife species that can be produced without affecting production in the food web of the ecosystem. In practice, we need to set indicators that show when the population is at the level we want it, at its production carrying capacity.

The logistic model is a very simple model for a closed population with continuous production. Nevertheless, it can be useful for thinking about what happens to real animals as the population increases. Atle Mysterud (2006) shows how deer are affected by increasing densities (Figure 6.3). Even at relatively low densities, male calf weights decrease, followed by female calf weights. The point is that changes in herbivores—and vegetation—begin to happen long before the population reaches the theoretical carrying capacity (K). When wildlife managers talk about carrying capacity, they usually do not think of K, but of the level at which a population should maintain productivity without depleting forage, which Chapman and Byron (2018) describe as production carrying capacity.

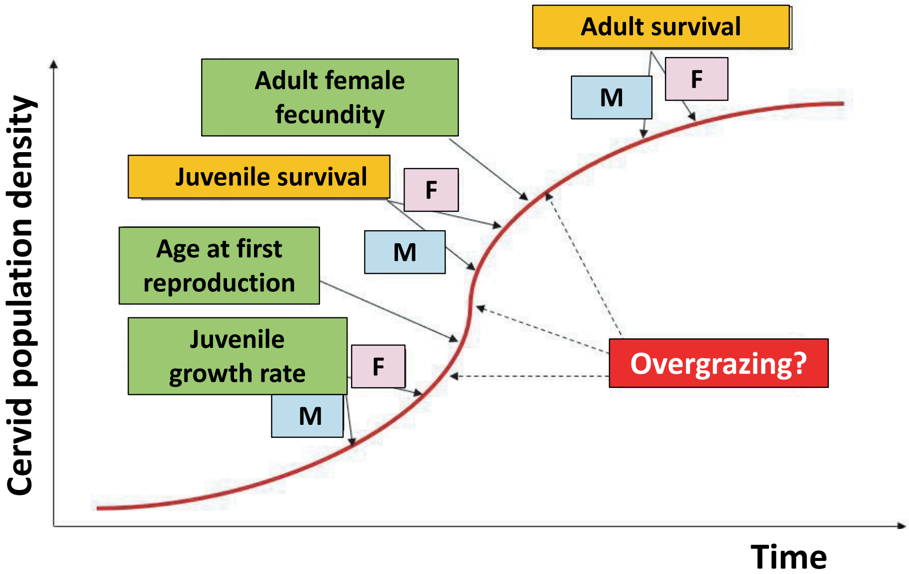

Figure 6.3: Reproduction and survival are gradually affected as population density increases. First, the weight of male juveniles decreases, followed then by that of female juveniles. As the population increases further, the age at sexual maturity and reproduction increases. Eventually, adult female survival will decrease at very high densities (adapted from Mysterud, 2006).

As the population increases from zero, production within the population also increases. According to the model, production is at its peak, and we can harvest the maximum sustainable yield when the population is half of the carrying capacity, K (Figure 6.2). When we harvest more than the growth of a population smaller than K/2, the population decreases rapidly; we say that mortality is additive. When we harvest more than the growth of a population larger than K/2, the population decreases—and production increases and counteracts the population decline; mortality is compensatory. According to the model, populations near K tolerate heavy harvesting. When the population is low, more precise harvesting is needed to prevent the population from decreasing. We can see that according to the logistic model, the population can produce as much at a density below K/2 as at a density far above. A lower population with less consumption of forage resources can produce as much as a large population that causes high grazing pressure. When the population is limited by food availability, we say it is limited from the bottom up. When the population is pressed down by predation, we say it is limited from the top down.

The classification of r- and K-selected species is relative. Large game species are generally more K-selected than more r-selected small game species. Ptarmigan are smaller, lay more eggs, and have shorter lifespans than more K-selected larger capercaillies with slightly fewer, larger eggs and longer lifespans. However, small puffins are far more K-selected than large wild boars and wolves. It may be just as useful to define species as fast or slow. Comparative analyses show that long-lived species and populations far below carrying capacity tolerate less harvesting (compensate less) than short-lived species and populations near carrying capacity (Peron, 2013). Managers can influence the carrying capacity of wildlife species. If winter forage determines the carrying capacity for Norwegian moose, carrying capacity can be increased through forestry measures such as cutting pine trees and piling waste from this as supplemental forage in winter range. Managers can also alter production in a moose population by choosing culling strategies; for example, maintaining a large proportion of adult cows in the population can increase production.

The growth factor λ (lambda) for a population indicates how it changes over time. If the population increases by 5% in one year, $\lambda = 1 + 0.05 = 1.05$. The growth factor changes from year to year and must be close to 1 over time for the population to be relatively stable. It can be useful to calculate λ for subpopulations. It may be that the population produces a surplus in some habitats (source areas), and this surplus compensates for deficits in other habitats (sink areas). If high λ can be linked to specific habitat elements, these elements can be promoted to improve conditions for the species. Coates et al. (2018) have looked at how precipitation has been positively correlated with λ for sage grouse living in dry areas. It can be particularly interesting to link λ to human interventions and installations. For example, Coates et al. (2018) found that the growth factor was low near power lines where ravens could nest and raid sage grouse nests. A good measure for sage grouse was to prevent the construction of power lines and, if possible, remove old ones.

In the Habitats Directive, the EU uses the term “favorable conservation status” for species—without it being entirely clear what that means. Trouwborst et al. (2017) discuss what the term means for large predators. They believe it is difficult to determine the carrying capacity for predators near settlements because humans do not want too many predators. To find favorable conservation status, one must start with what is needed in terms of biology to be fairly certain that the species will be able to survive in the long term.

CONDITIONS

Physical conditions set boundaries for where wildlife species can exist. Wildlife species are adapted to the usual, and unusual extreme conditions are unexpected and can pose challenges. Extreme weather and climate can significantly impact the size of wildlife populations, especially in northern regions (Hunter et al., 2010; Gilg et al., 2012). Icing of winter forage in wild reindeer mountains can hinder access to lichens and lead to starvation (Tyler 2010), while warm summers enhance harassing insects, parasites and disease (Tryland & Kutz, 2018). Deep snow and low temperatures decimated some roe deer populations in Eastern Norway during the winter of the 1994 Lillehammer Olympics (Andersen et al., 1996). Larger deer species can also struggle under extreme weather conditions. Red deer struggle in snowy, cold winters (Loison & Langvatn, 1998; Loison et al., 1999), and milder climates can partially explain range expansion in this species across Norway in recent decades (Solberg et al., 2022). Moose in North America, however, may have been negatively impacted by warming with heat stress and increased parasite loads (Weiskopf et al., 2019; Hoy et al., 2018). Climate changes can negatively affect both small rodent cycles and grouse populations (Henden et al., 2019). Lack of snowfall can make white hares more vulnerable to predation in winter (Pedersen et al., 1995; Pedersen & Pedersen, 2012).

SOME LIMITING FACTORS

One or more factors can limit wildlife populations far below the theoretical carrying capacity, K. In wildlife management literature, it is common to illustrate carrying capacity with a barrel. The water content of the entire barrel represents how much wildlife could be in the habitat. However, some staves of the barrel are shorter, and when water is added, it spills over the lowest stave. For example, it is useless to maintain a dense puffin population if there are plenty of safe nesting places and enough food for adults throughout the year, but not enough food for chicks. The lowest stave here is chick food. There will be no dense puffin population until there is enough chick food; thus, chick food becomes the minimum factor. The stave model is somewhat static, as the shortest stave will vary, and often several staves are short.

A minimum factor can be predation. The view on predation and predators has changed over time (Breisjøberget, 2013). In 1845, a unanimous Parliament passed a law for the eradication of wolves, bears, lynxes, wolverines, golden eagles, white-tailed eagles, eagle owls and goshawks. The red fox was considered useful because it had good fur (Richardsen, 2012). In the early 1900s, the fox was no longer useful. NJFF launched The Great Predator War, and ptarmigan populations were very good until they crashed in 1912 (Søilen & Brainerd, 1996). Subsequently, it was questioned whether predator control might not be effective after all. Errington (1956) wrote that predation can eradicate species but showed that muskrats with territories survived, while the others, "the doomed surplus," were killed by predators. The notion that those with territories survived was supported by red grouse research in Scotland—where gamekeepers kept grouse moors free of predators. The prevailing attitude became that predators never had an impact on wildlife populations. When wildlife was later radio-tagged, researchers saw that predators often have a significant impact on the size of prey populations, especially at the start of the hunting season in autumn.

Andersen et al. (2006) thoroughly review how large predators affect ecosystems in northern areas. It is highly situational and depends on 1) the number of predator species in the area, 2) availability of alternative prey 3) food competition among prey, 4) human harvesting of predators and prey and 5) the mobility of prey. It seems clear that most large predators can significantly reduce the populations of large prey species. It is accepted that both food availability and predation influence population dynamics.

In Alaska, researchers have been concerned with the relationship between grizzly bears, black bears, wolves and moose (Gasaway et al., 1992; Messier, 1994). Many moose populations seemed to be far below what food availability would suggest. It was discussed whether predators could keep moose at a low level, a predator pit, but also whether the moose population could maintain a high equilibrium point with predators if it increased to near carrying capacity. However, there is no real equilibrium between dense moose populations and predators; that is to say, moose populations grow so large that they eventually become nutritionally limited and need to be managed through harvest to avoid crashing (e.g., Boertje et al., 2007); however, predators can limit moose populations at low densities—the low-density dynamic equilibrium described by Gasaway et al. (1992).

While author Brainerd worked for the Alaska Department of Fish and Game in Fairbanks, first as a wildlife technician in the 1970s and more recently as research supervisor, he was involved in evaluating the impact of predator control of wolves, black bears and grizzly bears to increase moose and caribou populations for hunters. The work is not concluded, but it is clear that the removal of wolves and/or bears had the desired effect of increasing population growth rates and densities in some areas (Boertje et al., 2010; Keech et al., 2011), but not in others (Boertje et al., 2017; Miller et al., 2022; Gasaway et al., 1992). In some areas with dense populations of wolves, grizzly bears and black bears, excessive predator control and insufficient harvest led to high-density moose populations that were limited by food availability (Boertje et al., 2007). Paragi et al. (2021) reviewed the impact on moose of well-documented wolf culling projects. They also found that moose populations increased in some areas but noted that each area and year were unique situations that should ideally be analyzed individually. The Alaska Department of Fish and Game (2025) has recently conducted an extensive review and evaluation of predator control programs and found that population objectives were met for three of seven moose programs (six increased in abundance) and one of four caribou programs (two increased in abundance), with other simultaneous factors, such as mild winters and wildland fire, positively or negatively influencing prey abundance responses.

Predation on forest grouse nests has increased from low to high levels during the post-war period, and in Norway, red foxes and martens are the most important egg predators (Jahren, 2017). In Scandinavia, two well-documented experiments where predators of forest grouse were attempted to be removed show that predation had an impact (Marcström et al., 1988; Henden et al., 2020). Egg predation appears to be a limiting factor for black grouse and capercaillie. Since Northern Norwegian hare populations on fox-free islands are dense (Huseby & Bø, 1986), it is easy to think that predation by foxes on the mainland is an important reason for the listing of hares as threatened on the Norwegian Red List, although there are other hypotheses (Pedersen & Pedersen, 2012).

When large predators are removed, populations of slightly smaller predators can increase significantly, known as "meso-predator release" (see Andersen et al., 2006). In the USA, the removal of wolves has led to an increase in coyote (*Canis latrans*) populations, resulting in harsher predation on the prey of coyotes (Flagel et al., 2017). Conversely, Newsome and Ripple (2014) found that coyotes outnumber red foxes where wolves are absent, but red foxes outnumber coyotes where wolves are present across North America. A good example from Scandinavia is that marten populations increased when mange decimated the red fox population (Lindström et al., 1995), although increased prey density may also have played a role (Lindström et al., 1994).

PARASITES AND DISEASES

Parasites thrive on their hosts. It is such a good life that 40% of known species on Earth are parasitic, with each bird species hosting an average of nearly 11 and mammals about eight different parasite species (Dobson et al., 2008). Avoiding parasites is an evolutionary force (Holmstad et al., 2005). Some parasites, ectoparasites, live on the outside of the host, while others, endoparasites, live inside the host animal. Parasites can be large, macroparasites, living outside or in cavities, or small, microparasites, usually living inside cells. If the parasite harms the host so much that the host dies, the parasite also dies—unless it is adapted to move to a new host that eats the dead host. Selection favors host animals with genetic traits that tolerate and resist the parasite and parasites that do not kill the host. A challenge for parasites is spreading offspring to other hosts. Many intricate pathways of spread, direct and via intermediate hosts, have evolved. Most wildlife species are hosts to many parasites. Some parasites stick to one primary host, while others can infect multiple species.

Many human diseases come from domestic animals. When they spread to humans, people lacked resistance. Many died, only the most resistant to diseases survived, and only the less harmful parasites lived long enough to infect new victims. Diamond (1997a) writes that measles and tuberculosis came from cattle, smallpox from cattle or other livestock, and the common cold from pigs and ducks. Europeans brought these and other diseases to America. Diamond (1997a) writes that probably 19 out of 20 million of the indigenous people in what is now the USA died. Thus, invading diseases helped European settlers take over the land (Dobyns, 1993).

Key rules for wildlife managers can be that parasites are common and pose little harm to healthy, well-fed animals but can be significant nuisances, especially when populations are large and animals are in a weakened condition. It can be very dramatic when new parasites enter populations where they have not been before and when parasites jump from one species to another. Infections spread more easily in dense populations and when animals gather at salt licks and feeding places.

Many parasites live on grouse species, and in dense populations, some can have limiting effects. There is much evidence that Scottish red grouse populations in Britain crash when the density of the intestinal worm becomes very high (Newborn & Foster 2002). Stenkewitz et al. (2016) found that almost all rock ptarmigans in Iceland were parasitized (99.7%) by a total of 16 different species. They found good evidence that the single-celled intestinal parasite *Eimeria muta* (a coccidiosis) affects density, condition, survival, and reproduction, thus influencing the population dynamics of rock ptarmigans in Iceland. When Norwegian ptarmigan populations collapsed after periods of intense predator control, findings of dead birds and diseases were reported (Hjeljord 2015). Brinkman (1926) believed they died of coccidiosis, which can spread in dense populations, while Steen (1978) writes that many dead ptarmigans were found in 1923–1924 without the causes of death being determined.

Parasitologist Per R. Holmstad has studied parasites in ptarmigan in Norway in recent times. He has found many different parasite species, that the parasite species correlated, and that when they are numerous, they are disadvantageous to the ptarmigan, with reduced weights and reproduction. He also showed that ptarmigan with more parasites tended to hide and sit harder for a dog than ptarmigan with fewer parasites (Holmstad et al., 2005, 2006, 2008). Holmstad studied ptarmigan in dense populations. Since 1923–1924, there have been no reported epidemics in Norwegian ptarmigan (Steen, 1978). Nor have there been such dense populations as reported in the early 20th century (Hjeljord, 2015). With the normally low ptarmigan densities we have in the Nordic countries, it seems that parasites are not a big problem. Nevertheless, wildlife managers should be aware that parasites can be significant, especially if ptarmigan populations were to be very dense over several years.

Hares also have many parasites. Author Storaas remembers well a wildlife veterinarian at the Veterinary Institute, Gunnar Holt, saying that when someone shot a hare, it was more like killing an entire zoo; the hare was full of microorganisms and parasites. He never touched a hare without rubber gloves. Nevertheless, Newey et al. (2007) write that hare populations in Fennoscandia are limited by predation and only occasionally reduced by tularemia.

All wildlife species are more or less troubled by their parasites. Deer have many (Figure 6.4). Wild reindeer are known to be heavily plagued (Tryland & Kutz, 2019). Reimers (2018) provides a good overview of diseases and parasites in our deer species. The Veterinary Institute monitors the health status of deer species and muskoxen (Madslien et al., 2022). Of all the diseases, we mention here the prion disease chronic wasting disease (CWD). CWD was discovered in wild reindeer in Nordfjella in the winter of 2016. CWD is a prion disease. Prion diseases are not caused by a parasite with genetic material but by a misfolded prion protein. Prion proteins exist in the body, and occasionally they can fold so that the structure is incorrect. When a misfolded prion encounters a healthy prion protein, this healthy one also changes form to misfolded. Misfolded prions are not broken down but accumulate in the central nervous system. Over time, accumulated misfolded prions in the brain lead to severe damage and death. Misfolded prions can be transmitted from animal to animal through contact, saliva and urine. Misfolded prions can survive for years on the ground and be absorbed by forage plants that are grazed by livestock. The risk of infection is greatest among flock-living animals and at gathering places such as salt licks. CWD is 100% fatal, but certain gene variants of reindeer are more resistant to taking up the altered protein. Wild reindeer have a higher frequency of genes that make them susceptible to infection than domestic reindeer.

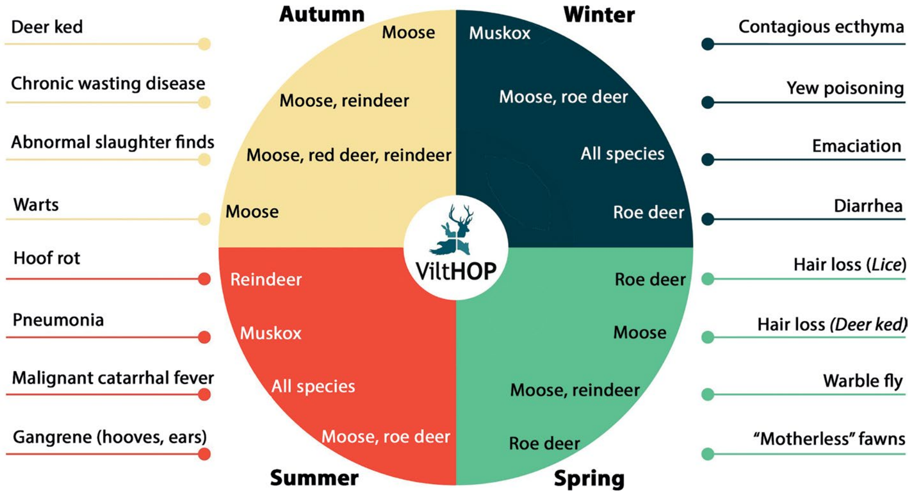

Figure 6.4: Annual cycle of cervid diseases and parasites indicating the most frequent maladies during different seasons and for which species they are most pertinent. Adapted from ViltHOP (Veterinærinstituttet, 2021).

The wild reindeer population in management zone 1 in Nordfjella was eradicated to prevent the spread of Chronic Wasting Disease (CWD) to other areas. In 2020, a buck and, in 2022, a doe with CWD were killed south of National Highway 7 on Hardanger Plateau. The Norwegian Scientific Committee for Food and Environment (VKM) appointed an expert group that gathered the latest knowledge and outlined three approaches to tackle the problem: 1) do nothing, 2) kill all the reindeer on the plateau and 3) a compromise solution (Ytrehus et al., 2021). They stated that if nothing was done, CWD would spread in the Hardanger Plateau wild reindeer population and potentially to other wild reindeer populations and other cervid species. However, there are many disadvantages to killing all the wild reindeer on the Hardanger Plateau. It is most likely that the infection is in large bucks, and the infection pressure will be lower if the population is reduced. The measure taken was to reduce the population size, decrease the proportion of large bucks, and maintain a young population. At the same time, the moose and red deer populations in and around the infected areas will likely be reduced. The future will show what measures are implemented and whether the disease spreads. CWD is a very serious threat to all deer species management in the Nordic countries.

Wildlife is also exposed to pollution. Hunters have largely used lead ammunition. Arnemo and Stokke (2014) found that meat from animals shot with lead bullets was contaminated with lead, and over 300 kg of lead remains annually in slaughter residues and carcasses after moose hunting in Sweden (Stokke et al., 2017). Fuchs et al. (2021) found high concentrations of lead in mothers, cubs and milk of carcass-eating bears in Scandinavia. There is broad agreement among researchers who have studied the topic about the harmful effects of lead ammunition. Lead shot is now banned in Norway, and lead bullets likely will be phased out in the future.

AUTHORS' REFLECTIONS

Author Storaas began studying ecology to find limiting factors for black grouse in Hardanger (chapter 1). After years at the universities of Bergen, Oslo, Idaho, and later at Inland Norway University of Applied Sciences, he knows a lot about forest grouse in general but is not aware of systematically collected knowledge about black grouse in Hardanger and can only speculate on limiting factors based on knowledge from other areas.

To understand how populations are influenced and developed, we depend on tracking the fate of individuals and monitoring populations. Author Brainerd participated in successful efforts to increase the moose population near Fairbanks in Alaska, where the interplay between research, manipulation of the wolf population, and hunting management yielded significant results over decades (Brainerd, 2023). Monitoring programs for individual species are needed (Chapter 7). It is also important to have long-term monitoring of various communities, such as Charles Krebs's work in Kluane in the Yukon Territory (Boonstra et al., 2018) and the work on the small game community in Varaldskogen (Wegge et al., 2022). Monitoring usually only provides probable hypotheses for causal relationships. Only large-scale experiments, such as red fox culling to promote Arctic foxes on the Varanger Peninsula (Henden et al., 2021), provide greater certainty. Greater certainty about causal relationships helps move wildlife management from art to science.

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7. Wildlife monitoring

Monitoring is one of the most important tasks of the wildlife manager (Krausman, 2013) and involves the systematic collection of data using reliable scientific methods. Monitoring methods can be inexpensive and easy for ordinary people to use, or they can be advanced, costly and require specialized expertise. In this chapter, we will 1) discuss how much knowledge we need, 2) review three main forms of monitoring with examples, 3) look at monitoring of nutritional condition, 4) discuss non-invasive monitoring methods that do not disturb wildlife, 5) provide an overview of Norwegian monitoring programs, 6) consider the role of laypeople in monitoring and 7) reflect on how monitoring can be further developed.

HOW MUCH KNOWLEDGE DO WE NEED?

Ideally, the wildlife manager should obtain data on the number of individuals, birth rate, death rate, causes of death, forage availability and health status with condition measures for all species. For huntable species, data on hunting efforts and harvest are also needed. Preferably, we would monitor all species in a community, but resources for monitoring are often limited. Usually, the manager manages wildlife on behalf of someone, a contracting authority, or a client organization that has specific goals for the monitoring.

The knowledge needed by the client about different species varies greatly. Many of the Norwegian Environment Agency's monitoring programs focus on individual species with specific challenges. The authorities want to manage the wolf population at a critically endangered level, which is a very small population. Accurate figures are needed on packs, pups in the packs, pairs, and individuals in Norway but also in neighboring Sweden, where most of the wolves in the Scandinavian population are. The genetic composition of individuals must be investigated, and immigrants must be protected to allow the introduction of new genes into the population. Based on extensive snow tracking, capture and GPS collaring of individuals, as well as collecting wolf scats for genetic testing, specialists can estimate the number of wolves in Norway with a high degree of certainty (Svensson et al., 2023).

Moose are managed within the framework of the Norwegian cervid regulation by municipalities and landowners. Pedersen et al. (2020, Chapter 3.1) estimated the socialeconomic value of moose hunting at 1.1 billion NOK during the hunting season 2019–2020. A capital yielding 1.1 billion NOK annually is substantial. Most hunting rights holders, municipalities and hunters still believe that knowledge of what hunters saw and shot the previous year (seen moose), and possibly an overview of moose browsing in young pine forests and moose collisions, is sufficient knowledge to manage the moose (Pedersen et al., 2021d). Most huntable small game species are managed without more knowledge than that they, according to the Norwegian Environment Agency's assessments, are doing well. For some species, like forest grouse, monitoring provides good assistance for hunting rights holders who want to manage harvest sustainably (Brainerd et al., 2005). The wildlife manager's task is to present to the client what monitoring methods are available, with cost and precision level. Together, they should be able to arrive at the best overall monitoring method to achieve the desired result for the client's goal.

Wildlife can be monitored at the individual, population, and species levels, and we can monitor the habitat of the wildlife. At the individual level, we can measure gender, age, weight, blood values and similar, but also what area it uses, offspring production, lifespan and cause of death. At the population level, we can find numbers and characteristics such as gender and age distribution and, over time, reproduction and death rates. We can find these values for all populations—and thus for the species. For habitats, one can map minimum factors such as food availability.

For population monitoring, methods can be divided into three main forms: 1) total (minimum) counts or census, with the goal of counting all individuals of a species in a study population, 2) sample counts where a portion of the study populations are observed and the population are estimated statistically and 3) indices where something related to population density is observed to describe trends over time and space.

TOTAL OR MINIMUM COUNTS (CENSUSES)

When all objects of interest in an area or population are observed, it is a total count or census, but since one can rarely be sure that all are observed, it is usually more accurate to call it a minimum count. Total counts are most suitable when the population, at least at one time of year, resides in a few, restricted areas where animals are highly visible and easily counted. This can be breeding areas for seabirds (not always including non-breeding juveniles), breeding areas for seals and sea lions (Phocidae) or areas of concentration for wild reindeer and caribou. Observers can, for example, photograph animals from boats or aircraft, count individuals from the images and thus determine population size and composition.

If all walruses (*Odobenus rosmarus*) haul out on a beach at a certain time of year, they can all be counted. The conditions are that all walruses are on land and that observers count at the places where the animals are located. If all deer graze on cultivated land in April, all deer may be counted. The challenge is to be sure whether all were on cultivated land at the same time; it is best to count multiple times. The counts provide minimum numbers for the deer population, not a true total number. Managers can find and photograph wild reindeer from aircraft in winter. The large caribou populations in Alaska and Canada have long been monitored by minimum counts with aerial photography of the herds on the summer calving grounds where animals are highly concentrated (Bergerud, 1982; Valkenburg et al., 2016; Boertje et al., 2017). The Western Arctic Caribou herd in Northwest Alaska was almost a half million animals at its largest (Haskell & Ballard, 2007). Counting from the photos afterward at the office was very demanding but is now fully digitalized and automated (Rasmussen, 2018). Minimum counts with aerial photos are also used in Norway (Jordhøy, 1998; Hardangervidda Villreinutval, 2023). If one wishes to estimate calf production, one can photograph the nursery herds from aircraft over higher areas and snow patches in the summer. During the rut in autumn, one can observe the gathered herds and record the sex and age of animals in composition counts.

Instead of directly observing individuals, minimum counts can be made through DNA samples from biological material. The brown bear population in Norway is monitored by minimum counting primarily using DNA analyses of scat and hair collected by SNO, predator contacts and others who are outdoors. DNA analyses identify individuals and provide information about new individuals, geographic spread and sex distribution. Data from female bears are used in models to calculate the number of cubs (Fløystad et al., 2020).

Capercaillies are often surveyed during spring at breeding sites (leks) during the spring mating season. This can be challenging since yearling and two-year-old males do not display every day at the same lek, the number of males displaying can vary at many leks (Mollet et al., 2015) and visual lek counts can underestimate capercaillie populations compared to counts based on DNA from collected scats and feathers (Jacob et al., 2010). Males and females observed at leks are thus not total counts but minimum numbers. It is particularly difficult to count females that move around in the trees and on the ground and may not be observed consistently at a given lek. The minimum number in an area can also be too high if young females and males are counted at several leks that they may visit during the observation period. Author Storaas was sure in 1982 that there were four males at Tharoberg lek in theVaraldskogen study area, until he had radio-marked four—and there were four unmarked still displaying on the lek.

For a number of species, it is very difficult to count all individuals. It is easier to count breeding units. How many intact breeding units exist tells something about how many wolf pups can be expected. Breeding wolf pairs live together with their offspring in territories where they defend against other wolf packs. Territorial wolf pack sizes can be estimated by collecting scats and snow tracking. Through genetic analyses, wolf researchers have a comprehensive overview of individuals in the Scandinavian wolf population of Norway and Sweden. Annual reports on the wolf situation are published (Wabakken et al., 2022). In Alaska, managers try to find and count all wolves in larger management areas by following tracks in the snow from the air (Gardner & Pamperin, 2014).

Since it is difficult to have an overview of all wolverines traveling over all mountains, one counts what is static and easier to count, the breeding dens. The Norwegian Parliament has set a target of 39 annual wolverine litters in Norway. People can report sightings on Skandobs.no when they see wolverine tracks. In late winter, SNO searches with snowmobiles and helicopters for wolverine tracks in tracking snow. Around breeding dens, wolverine tracks radiate out in a star shape. This gives SNO an overview of how many wolverine litters there are each year. Fresh reports can be found on www.rovdata.no.

The Parliament has set a national goal of 65 family groups of lynxes in Norway. It is difficult to differentiate the tracks of all lynxes, and it is challenging to find lynx scat for DNA analyses. It is easier to distinguish family groups—since they are fewer—and use more confined areas. Previously, volunteers walked survey lines during a snowy weekend in January to find lynx tracks. Author Brainerd was responsible for administering this system when he worked for the Norwegian Association of Hunters. The intention was to involve hunters in lynx monitoring to reduce data conflicts between hunters and managers since quotas were based on the number of family groups. However, the method was assessed and found to be inaccurate (Mattisson et al., 2014). The system has now been simplified. When someone sees tracks of a female lynx with cubs, they report it to a dedicated website[1] via an app or alternatively to the local predator contact, who verifies the observation. Biologists at Rovdata then use these data to calculate the number of lynx families. These calculations are based on models using the size of home ranges and how far radio-marked family groups have previously moved in different parts of the country (Linnell et al., 2007). The minimum distance between observations of different groups decreases with increased prey populations and increases with the number of days between observations. Observations must be more than 22 and 40 km apart during winter in areas with high and low prey populations to be

1 www.skandobs.no

considered different family groups. Researchers would like more data to improve the rules (Gervasi et al., 2013). The distance rule can misestimate the number of lynx families if the density of prey, roe deer, has changed. It can also be challenging if people in some areas do not report lynx tracks because they do not trust the management, which can lead to an underestimation of the population, which may lead to a closed season or reduced quota for lynx hunting, and thus even less trust in the management.

SAMPLE COUNTS

Counting all animals or breeding units in most populations is expensive and difficult. Therefore, methods are often used where not all individuals need to be observed, yet one can calculate population size and the uncertainty in the estimate using statistical methods (Brainerd et al., 2005). It is common to establish various forms of sample plots. But we can also start with individuals, as in capture and release methods. We first look at sample plot methods.

Sample plots can vary in size and shape. The observer can observe individuals in an area from a point, in a sample plot, or at varying distances along a line transect. By finding the number of individuals in each sample plot, one obtains an estimate of individuals per unit area. If individuals are evenly distributed in the terrain, one will find roughly the same number per unit area in each sample plot, with little variation between plots, and the calculated estimate will be precise, meaning there is little variation around the estimate. If individuals are clustered in the terrain, there will be significant variation between sample plots, and the estimate will be less precise. An estimate may be accurate if it is close to the true population's size but may be imprecise if the variation around the estimate is large. On the other hand, a precise estimate may exhibit little variation around the estimate but may not be an accurate estimate of the actual population size. Ideally, we want our estimates to be as precise and accurate as possible.

When surveying a sample plot, it is crucial to know what proportion of a population is found during sampling. Author Storaas surveyed forest grouse about 40 years ago, dividing the forest into approximately 0.5 km^2 plots—and used good bird dogs in an attempt to find all the birds there. Afterward, he said: "We found all of them". Since he could not possibly know what proportion of individuals he found, he later dared not believe or use the population estimates. To calculate credible numbers of individuals per unit area, we need to know roughly what proportion of the population is detected in the sample plots. Without knowing this, a precise estimate can be very inaccurate and show completely incorrect numbers of individuals per unit area. One can be fooled into believing that a precise estimate is a good estimate, when it is in fact biased.

When planning surveys, we must consider:

1. Sample plots must represent the area the population uses. If we place sample plots only in the best areas, we will get population estimates for the best area. We will not know the population size in the entire area used by the population. If we have enough information, it may be useful to stratify a population into low, medium and high-density strata to get better estimates.
2. We must know what proportion of the population in the sample plots is detected and ideally what factors influence detection frequency.
3. We must establish and survey sample plots so that the findings of individuals in one plot do not affect how many we find in other plots.

The proportion of individuals detected in sample plots varies between surveys. Wegge and Storaas (2009) counted deer, antelopes and wild boars in sample plots to calculate the density of prey for tigers in a jungle in Nepal. All radio-marked animals were detected during the counts. Therefore, it is reasonable to believe that they also found almost all unmarked animals, and since the density estimates matched estimates from other survey methods this increased confidence in the estimates. In Finland, wildlife researchers have an extensive system of so-called wildlife triangles, which are comprised of 4-km-long transects conjoined in an isosceles triangle in representative areas throughout the country. Every August, 800–900 three-person teams of Finnish hunters walk within 20 m distance between observers in three-man chain line transects for estimating the abundance of capercaillie and black grouse (Helle & Lindström, 1991; Helle et al., 2016). They estimate finding 80% of the forest grouse in the 60-m-wide belt along the triangle sides and estimate density based on the fixed area of these transects based on width and length. This is based on a study by Brittas and Karlbom (1990). It is very likely that detection frequency varies significantly with location, time and weather conditions and functions as much as an index as an estimate of density.

Author Brainerd supervised moose research conducted by the Alaska Department of Fish and Game in interior Alaska. Moose are a vital resource for Alaskans, and substantial funds are allocated for monitoring and research. They have developed a monitoring method based on the use of fixed-wing aircraft that conduct counts within randomly selected survey blocks stratified in a gradient of low to high moose densities. The geospatial population estimator (GSPE) is a model-based analytical method used to estimate moose populations from selected sample plots over larger areas (Ver Hoef, 2008) and largely replaced the design-based double-sampling protocol developed by Gasaway et al. (1986) in the late 1990s. The main advantage of the GSPE is that it uses spatial autocorrelation among count units to enhance estimation, meaning nearby units with many moose likely indicate more moose in adjacent areas. Over 500 moose surveys in Alaska and Canada have been conducted and analyzed using the GSPE protocol (Kellie & DeLong, 2006; Higham et al., 2021) and software (DeLong 2006; Kellie & DeLong 2006).

For the GSPE, biologists randomly select sample plots covering 20–30% of the area to be surveyed, and based on previous knowledge, they classify these sample plots as areas with high or low moose density (desktop stratification). The best approach would be to conduct aerial reconnaissance before each survey (Kellie & DeLong, 2006). Biologists consider snow conditions, the experience level of the crew and forest density. They spend more time where conditions are difficult. They assume that moose are not randomly distributed in the terrain and circle around, searching more where they find moose. They search until they believe they have found all the moose. Subsequently, biologists use small aircraft to locate radio-marked moose to determine what proportion of the radio-marked moose the initial observers found, in order to adjust estimates for detectability, known as a sightability correction factor (SCF; Paragi et al., 2017). Schmidt et al. (2022) have improved the model by making it more flexible using Bayesian methods. Due to changes in snow conditions caused by global warming, work has begun to improve the method (Smith 2018). The work has resulted in reliable estimates of moose populations with distribution by sex and age. Consistent collection and analysis methodology has made it easier to compare across time and space, resulting in one of the most successful monitoring programs for large mammals in Alaska. Unfortunately, climate change has led to reduced snow cover, more challenging observation conditions and greater uncertainty (Kellie et al., 2019).

Knowing what proportion of a population we find is a major challenge. When people observe moose or deer from aircraft, the result depends on a number of factors:

1. Detection conditions: To find the animals, there should be complete snow cover on both the ground and trees. Ideally, it should have snowed a couple of days ago, so the animals have started to leave tracks. As soon as south-facing roots, stumps and mounds melt out, it becomes more difficult; we must check if the brown spots are wildlife or something else.
2. Type of helicopter or aircraft: The design of aircraft varies, and how easy it is to see the ground directly below will vary.

3. Observer inherent ability: Some people are fundamentally better at spotting wildlife than others. When landowner Niels Thomas joined author Storaas in the helicopter for the first time, he spotted moose, vomited in the air-sickness bag, spotted moose, vomited again and spotted moose repeatedly, mostly before the other observers saw the moose.
4. Observer experience: The more hours the observer has previously spent observing, the faster they detect objects—and will see a greater proportion of them. Only after several dozen hours of observation does the observation ability stabilize.
5. Open landscapes: It is easier to see wildlife in open terrain than in dense forest. In dense, closed spruce forests, it is difficult to see even large animals like moose from the air.
6. Number of animals together: It is easier to detect a herd than individual animals.
7. Distance from the aircraft to the animal: It is easiest to observe animals that are close.

It is difficult to know what proportion of animals we find. Fortunately, methods have been developed that can help us. Here we will review the methods of distance sampling and capture-recapture.

Distance sampling

Distance sampling is a form of sample count. The method can be used for both point sampling and line sampling. Instead of pre-determining the size of the area to be searched, one can later calculate the size of the area surveyed based on exact measurements. If conditions are good, animals may be detected at longer distances, which increases the areas surveyed; if conditions are poor, animals are seen at shorter distances, surveying smaller areas, requiring longer lines or more points to gather sufficient data (Buckland et al., 1993).

The advantage of distance sampling is that the method is based on few assumptions; in line sampling (Buckland et al., 1993), all (100% of) objects on the line or point are detected with certainty. Detection probability decreases the further animals are from the point or line. Objects are detected at their initial location. Resulting bias is negligible if movements are random. Bias will occur if animals flee or are attracted to the observer. Measurements (angles and distances) are exact. It is most important that distances near the line are correct.

When the assumptions are met, we can calculate the proportion of the population we detect. An advantage of line transects is that we can observe continuously while walking, whereas in point transects we have to move between points without observing between them. The commonality is that we calculate a distribution of observations from the observer's standpoint, and we can use the same software[2] to calculate densities with uncertainty.

For distance line transects, these must be randomly placed within the study area. It is often simplest to first delineate an area where we believe the density should be similar. Then we take a random starting point and lay out parallel lines at intervals long enough that observations on one line do not affect observations on the next line. We can observe from a platform such as a boat, aircraft, or elephant back, but we can also walk along the line.

Distance sampling has been successfully used to count insects, birds, mammals, and plants on land and in the sea. Author Brainerd conducted distance line-transect surveys of cetaceans as an observer on fishing boats in the Bering Sea and eastern Tropical Pacific in the 1980s, when the method was first being developed as a tool to assess the impacts of commercial fishing on stocks of dolpins and porpoises (Buckland et al., 1992). In Alaska, the method is used for surveying bears (Becker & Christ, 2015a, 2015b; Becker & Crowley, 2021), Dall sheep (Schmidt et al., 2012; Schmidt & Rattenbury, 2018), and moose (Peters et al., 2014; Wald & Nielson, 2014). In Sweden, operators found that distance sampling of moose from helicopters works well (Hörnell-Willebrand & Pehrsson, 2010; Edenius & Willebrand, 2011). The downside is that hiring helicopters is very expensive. For moose surveys, drones could become useful if they can fly along transect lines and measure distances to moose observed. Moose may be easier to detect using cameras with infrared sensors than with the regular color spectrum.

Brainerd et al. (2005) reviewed the literature and assessed survey methods for small game. In the UK, distance sampling without dogs was found adequate for capercaillie in winter, although they probably did not detect all birds on the line (Wilkinson et al., 2002; Catt et al., 2003). Finne and Wegge (2003) also did not find all individual birds on the line when surveying with dogs, but they found the broods. Brainerd et al. (2005) concluded that distance sampling with dogs is the best method for surveying forest grouse, despite the method likely underestimating forest grouse populations slightly. Today, distance sampling is the standard survey method for forest grouse in Norway and Sweden and is also used in Finland. The assumption is that surveyors find all birds on and near the survey lines. This holds true under normal conditions for grouse in

2 https://distancesampling.org/

the mountains in August, but not if it is hot and very dry in the forest. If someone surveys capercaillie and black grouse in the forest when it is dry and hot, both dogs and people will pass by birds both near and far from the line, and the result will be too low. The method is used by Statskog, the Finnmark Estate (FeFo), many mountain management boards and private individuals (Pedersen & Storaas, 2013a).

Let us take the example of ptarmigan surveys in Norway. The National Ptarmigan Survey is conducted throughout Norway in late summer prior to the hunting season, and the data are entered into a nationwide database known as "Hønsefuglportalen,"[3] or "The Grouse Portal" in English. This standardized system is based on distance line transect methodology, primarily for estimating the density and production of willow and rock ptarmigan (see Pedersen et al., 2004 for a description of methodology). On these transects, a team of two observers should walk together along the line. A dog is often employed if it can search along the line thoroughly. The line observer should walk on the designated line on the map. With only a compass, it can be difficult to stay exactly on course in the terrain, but it's not a big issue as long as they try. Today, most use GPS, making it easier to stay on the line. We define the line to run between the line observer's feet, where all objects of interest should be found regardless of whether they are exactly on the line or slightly to the side. The other observer should walk with the first observer but can also leave the line and focus on observing the objects of interest. This person should record how many individuals are together (if the individuals are in groups) and, together with the line observer, measure the distance from the line to where the object was when first detected. However, only objects observed from the line should count. The most important information to be collected includes 1) the distance traveled along the line, 2) the number of individuals in a group for each observation and 3) the perpendicular distance each observation was from the line. Additional information can be collected, but only these three variables are required to calculate the density.

When these assumptions are met, we can calculate the proportion of the population we detect. An advantage of line transects is that we can observe continuously while walking, whereas in point transects we have to move between points without recording observations between them. The commonality is that we calculate a distribution of observations at different distances from the observer, and we can use the same software to estimate densities with a measure of precision (Thomas et al., 2010).

3 https://honsefugl.nina.no/

By measuring distances accurately, the software can create a detection curve that shows how it becomes less likely to detect an object with increasing perpendicular distance. On the transect line where the line person walks, they find all objects; far enough away, they find none. The distances to the objects they find define the curve. The value of observations near the line is greatest, so one should search most near the line. When one gets so far from the line that only 15% of what is found on and near the line is observed, one usually cuts off and does not use observations made farther away. One should try to stay on the line laid out on the map, but measurements should be made from the real line walked, measuring from the line between the line observer's feet. The software calculates the distance from the line where the number of birds found farther away corresponds to the number of birds present but not found closer to the line. This distance on both sides of the line multiplied by the length walked gives the area surveyed (Figure 7.1).

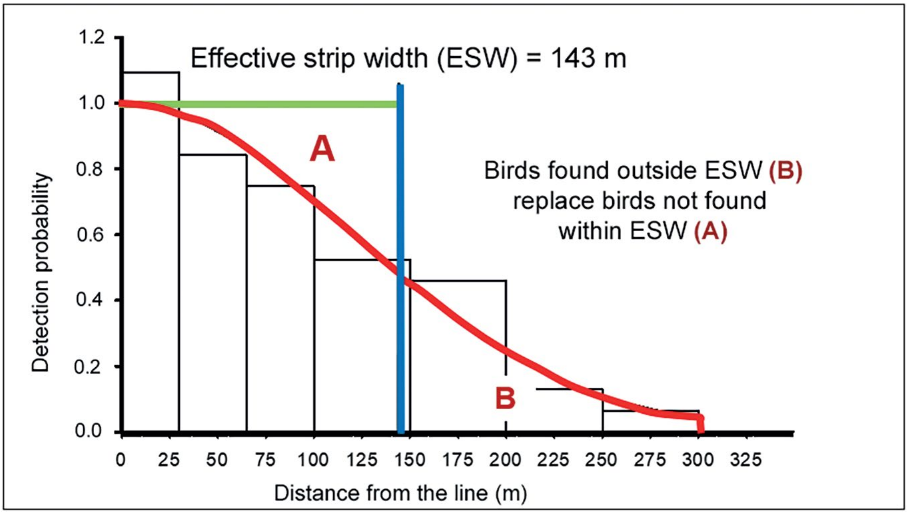

Figure 7.1: Distance sampling along transects in a ptarmigan study area. Observers find all birds on and near the transect line and observations decrease further from the line. Based on the distances from the line to the observations, the software Distance calculates the detection curve (red) and the effective strip width (ESW; blue line). At the ESW, the number of birds under the area (A) corresponds to the number of birds found outside the ESW (B). The total number of birds detected thus corresponds to all birds found with the ESW of 143 m. The area surveyed is thus twice the ESW (on both sides of the line) multiplied by the length of the transect. The area for calculating density is simply the ESW x 2 x (length of transect).

If we find more objects away from the line rather than on or near it, the sample size is either too low or assumptions are being violated. Good detection probability functions require many observations as a rule. How many can be debated? However, if single objects are always detected, fewer observations are required than in cases where there is significant variation in group sizes. For best precision, all available objects should be found along all lines. Buckland et al. (1993) state that as a rule of thumb at least 40 observations are required to make a reliable density calculation. In cases where sample sizes are too low to calculate density, we know the density is very low and other methods should be considered.

Author Brainerd attempted a grizzly bear survey using distance sampling from fixed-wing aircraft when bears were emerging from their dens in the Alaska Range south of Fairbanks but had to halt it after it became apparent that even in a very large area such a sample size would be impossible to achieve due to low observability. In that case, it was decided to use the capture-mark-recapture method (see next section) as it was more economically effective to actively search for bears with a helicopter rather than hope to see one on a line transect using a small fixed-wing aircraft during the short period when bears were emerging from dens in May above the tree line. So, there is a breakpoint regarding time and cost where distance sampling is ineffective at very low population densities and/or detection rates where other methods should be considered.

Author Storaas surveyed deer, antelopes, wild boars and monkeys from the back of domesticated elephants in the jungle of Nepal. Initially, he tried surveying the wildlife on foot. It was ineffective, and the observer typically only heard animals running away in the tall grass or forest. He then tried surveying from the elephant's back. This elevated the observer enough to see wildlife over the grass and bushes. The wildlife were not afraid of elephants and simply moved away slowly. The method was tested against other methods and worked exceptionally well (Wegge & Storaas, 2009).

For distance point sampling, the observer stands or sits in one place and measures the distance to objects of interest during a short time to avoid counting the same individual multiple times. Point sampling is common for counting singing male birds in spring. The idea here is that birds move slightly away from the observer, so there is an observer-induced bias although fewer birds are heard further away from the observer. By measuring the distances to singing birds, we can create a detection probability distribution curve; from the curve and observations, we can calculate the area surveyed and derive an estimate of bird density.

Capture-mark-recapture method

The capture-mark-recapture (CMR) method (or Lincoln index[4]) involves capturing a number of individuals from a population and marking them with tags, collars or other identifiers. Shortly after, a new group of individuals is captured, and the number with marks from the previous capture is noted (see Lindberg, 2012). It estimates population size (N) with the equation: N = (M * C) / R where M is the number of individuals initially marked, C is the total number captured in the second sample, and R is the number of recaptured marked individuals.

The method relies on many assumptions: 1) Marked individuals must be representative of the population, 2) capture and marking do not affect the behavior or fate of marked individuals, 3) marks do not fall off or are misread, 4) it is equally likely to capture marked and unmarked individuals in the population, 5) the fate of each marked animal is independent of the fate of other animals and 6) birth, death, immigration and emigration must not occur during the sampling process. Thus, the method is not suitable for many species since some become "trap happy." For example, a local inhabitant in our study area, Lauritz in the Varaldskogen study area, told us he caught a badger in a fox trap. He could not kill the badger because his wife, Elsa, believed that the badger was the pet pig of the forest gnome. Thus, the badger stood in the trap every morning, eating, and Lauritz had to drive the badger far enough away so that it could not find its way back. Roe deer can also become fond of eating bait in the trap. For a fox that goes into a trap, after it is released it will not go into the trap again. For capture-recapture to yield accurate results, the animal must be equally likely to enter the trap regardless of how many times it has been captured.

Author Brainerd and his colleague Morten Odden are currently developing a method for estimating pine marten populations in Norway using DNA CMR methodology. Martens visit baited traps in summer, and when they take the bait, some of their hair is snagged and can be analyzed to identify individuals. In England, pine marten populations are monitored by using the unique markings on their throats (Vincent Wildlife Trust 2020). Morten Odden hopes to develop a system where a pine marten can be simultaneously identified by its markings and DNA, but this is proving to be quite challenging. Magoun et al. (2011) have developed such a method for wolverines where they are attracted to bait in such a manner that they expose their unique chest markings at the same time as small clips take hair samples. Individual Eurasian lynx can be easily identified by their unique spot patterns, which can be useful for non-invasive CMR studies (Breitenmoser et al., 2006). Any species with unique identifying markings can be monitored using CMR methods without the need for invasive sampling (i.e., capture and marking).

4 https://archive.org/details/calculatingwater118linc/mode/2up

The capture-recapture method exists in many variants and can be adapted to different purposes. The method is often used when collecting DNA samples. For over 20 years, Swedish and Norwegian authorities have identified wolves, brown bears and wolverines using DNA from feces, urine and hair. This is used by Rovbasen to map individual predators in time and space and provide minimum counts. The RovQuant project has developed statistical methods to provide comprehensive assessments of population status and dynamics based on capture-recapture of DNA data and other information collected by national monitoring programs in Sweden and Norway (Bischof et al., 2022). They have developed a Bayesian open spatial capture–recapture model that uses DNA collected in the field together with samples from dead predators to estimate 1) the spatial variation in the likelihood of detecting genetic traces, 2) the spatial distribution of individuals over the years and 3) population size and dynamics. Rivest et al. (1998) devised a method to estimate the number of caribou not seen during photo census flights, which has been incorporated recently in Alaska by author Brainerd's colleagues. So here we have a case where two types of methods are integrated: minimum count (census) and statistical sampling to determine the proportion of animals not directly observed. This illustrates that methods of assessing wildlife numbers are constantly evolving and being refined and that some methods overlap between the three traditional categories for assessing wildlife abundance.

INDEX COUNTS

Index counts do not directly indicate how many animals there are but rather correlate with the number of animals in the population. Indices can be easy to collect, but they are influenced by known and unknown factors, and the relationship between index and population is usually unknown. Nevertheless, a good index correlates with population trends over time and between areas. Animals observed per hunter-day can be an index. How many animals are harvested per day or year can be another. Indices are widely used and are often very useful, but the relationship between an index and a population can be influenced by many factors that may not be linear.

Harvest statistics

In Norway, all hunters must report harvested game to Statistics Norway (SSB). Harvest statistics are often used as an index to see how wildlife populations have changed over time; hunting can thus be useful for recording population changes. However, the amount harvested depends not only on population size but also on how the harvest is regulated. Harvest figures often do not capture changes in populations until afterward. Wildlife manager and lecturer Vidar Holthe used to compare managing based on harvest statistics to backing up with a trailer; when you realize the trailer is going the wrong way, you must correct with the wheel. Similarly, harvest statistics show afterward that the population is going the wrong way, and the harvest must be adjusted afterward. Harvest statistics can be useful for evaluating trends in moose populations but should be combined with other indices (see "Hunter observations of moose and red deer" section below; Ueno et al., 2014; Solberg et al., 2014).

For species where each individual is valuable and easily caught, harvest numbers can be high until there are almost no animals left. If a species is protected for a period—and no harvest is reported—it does not automatically mean the population was extinct during the protection period. If the value of meat or fur changes, it can also lead to changes in harvest effort and harvest statistics. It is reasonable to believe that hunting effort for fur-bearing animals like foxes and marten depends on fur prices (see Tillhagen, 1987). When the price of a fox skin equates to weeks of wages and a marten skin to months of work at the sawmill, it is reasonable to believe that many would rather trap and hunt fox and marten than go to work. When the price for the skin does not cover the skinning cost, it is reasonable to believe that the harvest effort decreases, if fur price is the primary motivating factor for harvesting a species.

Harvest results can also vary between years with changing weather during the period most people hunt—even if population size was the same. The authors have experienced grouse harvests seemingly being washed away in fog and wind during the first hunting week. How long birds stay well hidden from the hunter through the fall also varies. In some years, birds sit tight, hidden from hunters, toward the end of September. Other years, many early in the hunt have experienced going home empty-handed after seeing many birds that sat tight for dogs but took off before hunters arrived. If there are many birds, people will likely hunt more days through the fall, days when birds are less hidden and fewer are shot. This leads to fewer birds being shot per day, even if there were many birds.

Harvest results have been used to estimate chick production in grouse. It turns out that hunters during early hunting in Sweden more easily shoot males and hens than chicks, thus showing harvest lower than actual production (Asmyhr et al., 2012). Statistics on the sex and age of shot deer often tell as much about how quotas were distributed as about what was in the population.

Hunter observations of moose and red deer

While aerial surveys and pellet counts are costly and sporadic, indices from moose observation data offer a cheaper alternative, providing estimates as precise as aerial surveys across diverse environments and regions (Rönnegård et al., 2008). In Norway, all teams that hunt moose or red deer register what they see during the hunt and the sex, age and weight of what animals they harvest. These data provide managers with a wealth of information with indices of trends in population size and condition. Ueno et al. (2014) evaluated the use of observations of moose and red deer during the hunt as compared to other indices. The main conclusion is that moose observations are a simple and useful way to obtain information, while red deer observations may be useful but sample sizes are too low and the method requires further evaluation, Here, Mysterud (2007) indicated that the form of hunting may have an influence on the number of red deer observed during a hunt. The indices have little value in smaller areas; at least 1,000 man-days (Ericsson & Wallin, 1994) or 400–500 observations (Solberg et al., 2006) may be needed before credible estimates can be obtained, although Rönneberg et al. (2008) found moose observations to be a useful index of long-term trend in a 135 km^2 study area in Sweden. The information we obtain can be divided into groups: 1) observed and harvested per hunting effort, 2) relationships between sex/age classes in the population and 3) trends in slaughter weight (nutritional condition).

In Norway, there is a website and associated smartphone app for recording the number of moose and red deer observed and harvested daily (i.e., Viltrapporten.no). Viltrapporten is a useful tool where users can access many statistics showing the development of moose populations. This is not an entirely accurate science. Managers must evaluate the various statistics and carefully decide on management measures.

1. Observed and harvested relative to hunting effort

The concept is that hunter observations are a reliable index to population trend over time; i.e., if hunters observe fewer animals per hunting effort (seen per unit effort or SPUE), the population has declined. Conversely, if they observe more animals per hunting effort, the population has increased. The indices of observed animals reflect interannual variation, especially for density indices such as animals seen per hunter-day, shot per hunter-day, number of animals seen, and number of animals shot. The best correlation was between the reconstructed population size and the number of moose shot and seen per km^2. When quotas vary, hunting effort often varies as well. It turns out that populations decrease or increase faster than observations per hunter-day change (Ueno et al., 2014; Solberg et al., 2014). Thus, managers must be especially careful when determining harvest quotas during population declines. Hatter (2001) shows that a particular moose is more easily spotted and likely shot when the population is low than when it is high. Fryxell et al. (2010) state that quotas often remain high until after the population starts to decline. If managers do not reduce quotas quickly and sufficiently, they risk that moose observations may be overly relied upon until suddenly there are almost no animals left.

Previously, an observation was divided by the number of hunters who saw the animal. The more hunters who observed the same animal, the lower the moose observation index. Ueno et al. (2014) suggested that only multiple observations of the same animal by the same hunter in the same drive should be censored from the data. In 2018, new rules were introduced in Norway. From then on, all hunters must register all the animals they see. Thus, when the rules for data collection change, we must be cautious in comparing moose observation before and after the change, as now more moose are observed per hunter-day even if the population is the same.

2. Relationship between population segments

Moose hunters note how many cows they see per bull, how many calves per cow, calves per cow with calves, and the proportion of reproductive cows to all cows observed. What animals they see can vary with hunting methods. If cows with calves stand more for baying hunting dogs, this segment will be overestimated in areas where this is a hunting method. But if hunters hunt in roughly the same way year after year in the same areas, this can be used as a good index for changes in the population. Solberg et al. (2014) found that the indices for cows per bull and calf per cow were less accurate than density indices from observed moose data.

3. Trends in slaughter weights

Slaughter weights can indicate population size relative to forage availability. The weights say the most about forage availability in the summer. If animals get plenty of good summer forage, weights are high. Low slaughter weights can result from too much grazing pressure on good forage plants, leaving little for each individual, typically density-dependent intraspecific competition. But weights can be low if the summer is dry and warm, even if there are large amounts of forage plants. Particularly dry and warm pre-summer can lead to poorer forage quality (e.g., Bø & Hjeljord, 1991). If forestry has reduced areas with highly productive clear-cut areas, nutrient availability may decrease. In Alaska, it is common to use production numbers, especially twin rate, to look at the relationship between population and forage basis (Boertje et al., 2007).

In some areas, moose populations expanded when livestock grazing decreased. The first moose that established themselves had very good grazing conditions with high slaughter weights, which decreased as the animals increased in number and there was less forage per animal. Weights can also decrease due to poor body condition as a result of reduced forage quality or increased parasite loads. If hunters focus on culling smaller, lower-quality individuals, this will be reflected in the data with decreased slaughter weights in a short-term perspective. In contrast, if a high proportion of adult animals are harvested, this may skew the age structure to younger, smaller animals in the future, thereby decreasing average slaughter weights. Decline in a deer species can also be related to forage competition between species. Spitzer et al. (2021) found that dense roe deer populations competed with moose for nutritious bilberry (*Vaccinium myrtillus* L.) shrubs, thereby displacing moose to consume less nutritious pine.

A general rule might be to reduce the deer population when weights decrease, but it is not certain that weights will increase. Thorough analyses are required, and sometimes it might be most practical to accept that conditions have changed and weights have become lower.

Solberg et al. (2014) note that moose and deer monitoring is relatively inexpensive and occurs in areas where most hunting takes place, making the indices particularly useful for managing moose populations. As red deer data is collected over longer periods, it is expected that this data will also become more valuable.

Hunters are encouraged to enter observations and harvest information into the "Sett og skutt" (Seen and shot) system, preferably using an app, or by inputting data into systems like Viltrapporten.no, which forwards information to "Sett og skutt." Viltrapporten is a useful tool that provides users with various statistics showing the development of moose populations. While not entirely precise science, managers must evaluate the different statistics and make informed decisions regarding management strategies.

MONITORING RANGE CONDITION

Plants form the foundation of all life that lacks chlorophyll. Numerous habitat models have been developed based on recordings of plant species, plant structure and topography, which indicate where animal species are most likely to exist and thrive throughout the year (Boyce et al., 2016). In Norway, it can be important to monitor limiting factors such as the availability of winter forage for wild reindeer and moose, where population sizes are largely determined by hunting. Forage quality and quantity are an important component of carrying capacity of many wildlife species. Many habitat models have been created based on inventories of plant species, plant structure, and topography, which show where herbivorous species are most likely to exist and thrive throughout the year (Boyce et al., 2016). In Norway, it may be important to monitor minimum factors such as the availability of winter forage for wild reindeer and moose, where population sizes are largely determined by hunting rather than natural sources of mortality such as predation or winter kill.

Lichen inventories for wild reindeer

To assess the availability of reindeer grazing, researchers set out routes and measure in various ways according to their specific purposes (e.g., Kater & Baxter, 2022). For many Norwegian wild and domestic reindeer populations, lichen is preferred as winter forage and is often a limiting factor in many areas. For practical purposes, it is relatively simple to record whether lichen is increasing or decreasing in a given area. This allows trial and error to determine the optimal reindeer numbers in the area. The method is a combination of systematic fieldwork and judgment (Eilertsen, 2008). Gaare and Skogland (1980) developed a model to calculate the growth and consumption of lichen based on lichen surveys. The model can be used to calculate how many reindeer can be sustained per unit of lichen in an area. Lichen grazing is one of the factors measured in the quality norm for wild reindeer (Klima- og miljødepartementet, 2020). The measurement method combines satellite monitoring and field studies. Biomass is reported in grams/m^2, and wild reindeer areas are classified based on areas with different lichen weights.

Browse inventories for moose

The carrying capacity for moose is a production capacity (Chapman & Byron, 2018) determined by human needs. From a forest owner's perspective, summer browsing of species competing with commercially valuable spruce and pine is generally beneficial. However, winter browsing on young pine and occasionally the tops of small spruce can quickly lead to forest damage and long-term economic losses. Moose browse inventories are used to obtain objective measures of browsing pressure and forage availability in the forest. In Norway, Professor Knut Solbraa (2008) tested and developed methods which have been further developed by Jo Petter Grindstad (2014) by the forest company Glommen Skog SA. The Norwegian forestry school Skogkurs (2021) has developed courses in moose browse inventory methods. The Swedish Forestry Agency [5] has developed Äbin, a quality-assured assessment method for wildlife damage in young forests, and provides annual forage forecasts to better adapt the moose population to forage availability (Skogstyrelsen, 2021).

Grindstad (2014) in Glommen Mjøsen Skog SA suggests controlling moose population size by recording how heavily moose browse on valuable tree species in winter and provides suggestions on how browsing pressure should be assessed in the future. It recommends that no more than 35% of available tree biomass should

5 https://www.skogsstyrelsen.se/en/

be browsed. Grindstad (2014) also refers to the regeneration requirements in the Norwegian Forestry Act and concludes that at final harvest, 60–80 undamaged trees per hectare are needed. In harvest class II, there should be a minimum of 200 trees per hectare. Grindstad (2014) recommends managing by two goals: browsing pressure and the number of undamaged coniferous trees. He also recommends recording moose pellets in sample plots as an index of abundance. To ensure both authorities and forest owners trust the results, Grindstad (2014) suggests collaboration on both organization and financing.

Zimmermann et al. (2022) compared Norwegian and Swedish moose browse inventory methods. They show that the methods produce conflicting results and provide examples where forest stands that are considered undamaged according to the Norwegian method are destroyed according to the Swedish method. They suggest measuring the same indices on both sides of the border. They emphasize that the density of undamaged trees can be a valuable indicator for forestry. On the Norwegian side, browse inventories should be systematized, and a joint database should be established, preferably in the Norwegian cervid register. We believe a system like in Sweden, where the Forest Agency measures forest damage and makes forage forecasts, would be useful.

There is rapid development of remote sensing methods, which utilize data collected from satellites and aircraft. It is likely that forage resources will be measured by remote sensing in the future (Kastdalen & Bergsaker, 2020).

NON-INVASIVE MONITORING METHODS

Pellet group counts

Especially in Sweden, pellet-group counts have been used to determine the winter distribution and density of moose (Månsson, 2009). Månsson et al. (2011) found that the distribution of moose pellet groups across different habitats corresponded well with the distribution of GPS-marked moose. It corresponded with best survey routes where old pellet groups were removed during autumn, although it could be difficult to distinguish old from new dung. Pellet group counts show quite accurately where moose have been, but there is some uncertainty about how many there actually are, as defecation rates can be quite variable (Matala & Uotila, 2013).

Snow track surveys

Mammals reliably leave tracks in the snow. By walking transect lines on snow and counting all crossing tracks, observers can obtain indices of winter abundance and distribution for many species. Here, too, it is important to cover long distances and all types of terrain if one wants a good index for the population of a given species over a larger area. Snow tracking may be useful for assessing the number of individuals, either by collecting DNA from urine or feces, or tracking the animal to its resting site. This, however, is very time-consuming and not practical when assessing the abundance of common species. While a snow track survey will provide an index of the winter population, it may not provide a reliable index for species that may be elsewhere the rest of the year.

In the previously described Finnish triangle system used for summer grouse surveys, volunteers record animal tracks crossing these same transects in winter. These winter track count surveys have provided useful information about the population trends of mammals and grouse species (Helle et al., 2016). In Norway, volunteers have walked line transects (Linnell et al., 2007) to obtain an index of lynx abundance, with three days after snowfall being optimal. Not only lynx tracks, but also all other species crossing the transects have been recorded. The survey results have provided useful information about the distribution of small game and mesopredator species in space and time (Kurki et al., 1998, 2000; Breisjøberget et al., 2018).

Camera trapping

Wildlife cameras can provide indices and density estimates of wildlife populations. Camera traps can be used to obtain density estimates using distance point transect methodology (Howe et al., 2017) or Camera Trap Mark Resight (CTMR; Forti et al., 2022) when animals can be identified by tags or natural markings. The use of camera traps has increased significantly with the transition to digital cameras, expanding their use, and software for recognizing objects is improving. It is expected that the use of camera traps will solve more and more ecological mysteries (Delisle et al., 2021). For example, they have been used to examine species occurrence based on habitat and environmental conditions (e.g., Angoh et al., 2023). Bycatch data from camera traps can be used to assess diel activity patterns (Frey et al., 2017) and the timing of phenology in plants and animals (Hoffmeester et al., 2019). Camera traps also have been used to measure how fast animals move in terrain (Rowcliffe et al., 2016).

Green et al. (2020) review camera trap articles and offer improvement suggestions. They propose using laypeople to deploy and maintain camera traps. The Scandinavian project SCANDCAM[6] has been successful in this regard. Camera traps can produce vast amounts of data, and as software develops, camera traps will likely be used more extensively. Camera traps are excellent, but when using them, we must remember the fundamental principles and uncertainties behind population

6 https://www.nina.no/Naturmangfold/Rovvilt/SCANDCAM

estimation (Burton et al., 2015). Many hunters and landowners have wildlife cameras in their hunting areas and monitor species of interest. Collaboration between hunters with wildlife cameras and researchers can provide substantial data.

Acoustic monitoring

Animals can be monitored by the sounds they make. Hazel grouse whistles have long been used in hunting and surveying hazel grouse (see Swenson, 1991; Swenson & Brainerd, 1998). When the whistle is blown, the grouse responds and approaches. Passive acoustic sensors are stationary and record sounds. They can record all they detect or be programmed to record specific sounds. Author Brainerd and colleague Torfinn Jahren have used acoustic sensing equipment (sound boxes) for hazel grouse surveys. These sound boxes and software are rapidly evolving. Initially, they were used to identify birds present in an area. A sound box could detect and inform us if an eagle owl called or a capercaillie had displayed. Since 2014, the use of sound boxes has led to an increasing number of articles estimating bird densities (Perez-Granados & Traba, 2021). Multiple microphones capture sound, angle and time differences taken by sound traveling from the bird to different microphones; software identifies the bird and calculates where it was singing.

Sound boxes are also used to estimate the densities of ungulates (Salem et al., 2021) but are predominantly used for bats, marine mammals and birds (Gibb et al., 2019). Gibb et al. (2019) state that passive acoustic monitoring offers great opportunities but also challenges. It requires good sound sensors and well-designed studies. Many sounds are recorded in various sound boxes, requiring organization and coordination. Sounds must be identified and statistical analyses are needed. This is work for computers and people knowledgeable about such matters.

Genetics

Each individual has a unique genetic fingerprint. Better methods are being developed for identifying individuals from different species through genetic techniques (DeSalle & Amato, 2004), and methods that hold forensic validity (Alacs et al., 2010), to trace poached animals back to species, sex and population. DeSalle and Amato (2004) show various ways genetics can aid wildlife management. Methods are used to determine the number of individuals of species like grizzly bears in the northern Rocky Mountains of the USA (Kendall et al., 2008), brown bears in Scandinavia (Bischof & Swenson, 2012; Bischof et al., 2016, Rovdata[7]) and red foxes (Wegge et al., 2019) in Norway. Author Brainerd and colleague Morten

7 http://rovdata.no/

Odden are currently developing a method to monitor pine martens using DNA-hair traps. As we have mentioned, the method RovQuant provides good estimates of the size and distribution of populations of bears, wolverines and wolves based on dead animals and fecal DNA in Scandinavia (Bischof et al., 2019). The Scandinavian Wolf Project (SKANDULV[8]) used genetic methods for constructing a complete pedigree of the recolonizing population, with a measure of inbreeding (Liberg et al., 2005). This method is challenging to use on lynx because lynx scat is rarely found. Genetic methods for determining population densities will be used more as analyses become cheaper.

NATIONAL WILDLIFE MONITORING IN NORWAY

Monitoring is important for the authorities who have established the Norwegian Biodiversity Information Center[9] to keep track of species and ecosystems in the country. The Species Data Bank has nearly 40 employees, works closely with biological science communities and publishes red lists and alien species lists. Monitoring is also crucial to determine if species can be hunted. The Nature Diversity Act § 16 states: "Harvesting can only be permitted when the best available documentation indicates that the species produces a harvestable surplus." Before each hunting season revision, a status overview for small game with population status and trends is prepared (Pedersen et al., 2021d). The Norwegian Environment Agency has several national monitoring programs and programs for impact monitoring of wildlife species and groups.

- **Terrestrial Nature Monitoring Program (TOV):** Monitors lichens and algae on trees, ground vegetation, small rodents, passerine birds, grouse, gyrfalcons and golden eagles across the country to detect any changes (Framstad et al., 2020).
- **Local Monitoring of Seabirds in Protected Areas (SEAPOP)[10]:** Monitors populations of nesting seabirds.
- **Environmental Toxins in Birds of Prey Eggs:** Part of TOV, conducted every five years to examine selected environmental toxins in birds of prey eggs.

8 https://www.slu.se/en/departments/ecology/research2/research/teman/wildlife-and-predators-/skandulv/

9 https://artsdatabanken.no/

10 https://seapop.no/en/

- **Monitoring of Terrestrial Breeding Birds (TOV-E)[11]:** Provides representative measures for changes in bird populations in terrestrial environments nationally and regionally organized by BirdLife Norway.
- **Monitoring Program for Cervids[12]:** Monitors the development of wild cervid populations and their natural environment using simple data from selected monitoring areas.
- **Bird Banding[13]:** Provides information about individuals, migration, reproduction and mortality. Banding is usually performed by volunteers but can also be part of various projects.

The Norwegian Environment Agency also has impact monitoring programs for wildlife including waterfowl, lesser white-fronted goose, bats, eagle owl, American mink, snowy owl, corncrake (*Crex crex*), black-tailed godwit (*Limosa limosa*), moor frog (*Rana arvalis*), Arctic fox, polar bear, muskox, raccoon dog and great crested newt (*Triturus cristatus*).

The Norwegian Environment Agency has established two internet portals to aid in the management of game populations.

- **Cervid Portal[14]:** Managed by NINA on behalf of the Norwegian Environment Agency, where wildlife managers find essential knowledge about cervid management and relevant news. The Cervid Portal has links to laws, regulations and the cervid register, where municipalities are required to enter data about cervids.
- **Grouse Portal[15]:** Still primarily a portal for those surveying grouse populations, but the ambition is to be the gateway to all relevant information about forest grouse.

For predators, there are two portals:

- **Rovdata.no:** Provides population numbers and comprehensive, up-to-date information about large carnivores and golden eagles. They have developed an app where ordinary people can report observations.
- **Rovbasen.no:** A tool used by managers to record observations of large carnivores and golden eagles for management purposes.

11 https://hekkefuglovervakingen.nina.no/Fugl/Default.aspx?ReturnUrl=/Fugl/
12 https://hjortevilt.no/forskning-og-viltovervaking
13 https://www.ringmerking.no/cr/
14 https://hjortevilt.no/
15 https://honsefugl.nina.no/Innsyn/nb

The Norwegian Wild Reindeer Council has the website:

- **Villrein.no:** A knowledge source about wild reindeer and their management.

The Norwegian Institute for Nature Research (NINA) runs the project:

- **SCANDCAM:** Monitors mammal populations with wildlife cameras and develops wildlife cameras as tools for research and monitoring.

Statistics Norway maintains:

- **Hunting Statistics**[16]**:** Collected from all hunting in Norway.

BirdLife Norway (formerly the Norwegian Ornithological Society) organizes:

- **Bird feeder monitoring**[17]**:** Where people can submit information about birds at feeding stations.

The Veterinary Institute administers the:

- **Wildlife Health Monitoring Program (ViltHOP)**[18]**:** This program provides an overview of and knowledge about the health status of Norwegian wildlife populations (Madslien et al., 2021).

Viltrapporten[19] is a privately owned digital solution that simplifies all administration related to hunting management.

THE ROLE OF CITIZEN SCIENCE IN MONITORING

Looking at the monitoring and surveying of wildlife species in the previous chapter, we are struck by how much knowledge is gathered by laypeople. Anyone can register observations through various apps, and many ordinary citizens provide camera data to the SCANDCAM project. Laypeople in BirdLife Norway monitor birds. Hunters report harvested game. Moose management is based on hunter

16 https://www.ssb.no/jord-skog-jakt-og-fiskeri/jakt
17 https://www.birdlife.no/organisasjonen/nyheter/?id=3637
18 https://www.vetinst.no/dyr/vilt/hop
19 https://www.viltrapporten.no

observations of living animals and data from dead animals harvested and provided by hunters. Effective grouse management is based on thousands of volunteer survey days following strict guidelines. Cretois et al. (2020) examined the role hunters play in monitoring biodiversity in Europe. Hunters participate in collecting data on predators, deer, hares and game birds on land and at sea. Hunters collect many types of data, conduct surveys and track observations in snow before hunting, report what is observed during hunting, what is harvested, collect scat samples for DNA analysis and participate in monitoring with camera traps. Cretois et al. (2020) conclude that hunters have a key role in biodiversity monitoring and that collaboration between hunters and scientists is fruitful. It is essential to evaluate data collection so that data is reliable and secured for the future.

AUTHORS' REFLECTIONS

Monitoring can be divided into 1) professional monitoring and 2) fieldwork performed by volunteers or mandated unpaid monitoring. The future will likely be a combination of the two. There is rapid development of remote sensing methods from satellites and aircraft (including drones with infrared sensors), and these methods will likely improve and make monitoring much cheaper, while improving precision and accuracy. Forsyth et al. (2022) have examined methods for calculating population sizes of deer. They point toward capture–recapture of DNA from biological material and motion-triggered wildlife cameras. Machine learning and artificial intelligence can improve and simplify the calculation of population estimates from both wildlife cameras and images from aircraft, where drones may be the future. The structure of data collection methodology and data processing will be specialist work. Collection of biological material and management of camera traps can be done by interested volunteers or members of organizations for moderate compensation.

It is easiest to get volunteers when they can engage in activities they enjoy. Bird dog owners can walk in mountains and forests with well-trained dogs during leash season when surveying grouse or forest grouse. For many of us, this is far more valuable than money. When people are out anyway, it can be easy to collect predator scat if it is easy to deliver it further. It may be more challenging to get volunteers to survey moose browsing damage or count moose dung piles in sample plots. Counting from helicopters and planes is expensive and will also be for specialists. Hunters can expect to continue reporting "Observed and shot" data for big game in the future, and perhaps in greater detail for small game as well. Camera traps, audio traps, and collecting scat for genetic samples do not disturb the wildlife. It is reasonable to believe that such methods will be developed and used more extensively where possible.

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8. From art to science: operating under great uncertainty

In the introduction to this book, we defined wildlife management as "a goal-oriented process involving actions and learning to influence interactions between wildlife, habitat and humans to achieve desired outcomes in consultation with stakeholder groups based on the best available knowledge and practices". There can often be significant disagreement about goals, and the process of setting goals can be challenging. It can be even more difficult to determine which actions will help us to achieve the goal. In this chapter, we will point out how complex nature is and show how authorities set goals and classify species. We will demonstrate how managers can approach interest groups to set goals and choose actions, as well as show how learning can occur through adaptive management.

COMPLEXITY, CHANGE AND CHANCE

Nobel laureate in economics, Daniel Kahneman (2012) has shown that economists cannot foresee how the economy will develop, nor where to invest for maximum future return. All investors try to predict the future, and while some succeed, Kahneman has shown that this is based on luck. When enough people make guesses, someone will always guess correctly. No one can know in advance which companies will win or lose.

Nature is far more complex than the economy. Professor Rolf Peterson has studied a simple system with vegetation, moose and wolves for over 50 years on Isle Royale in Lake Superior. When author Storaas asked, How will the moose and wolves fare next year? he shrugged and replied: Complexity, change and chance. With over 50 years of experience in a system with three species groups, he could not predict what would happen. Even this simple island system was too complex; experience showed that it changed all the time and unexpected, random events occurred. Such a random event was when a dog with distemper visited Isle Royale, infected the wolves and decimated the wolf population. The population increased before it decreased and eventually died out due to inbreeding. Then suddenly, a new wolf with fresh genes crossed the ice to the island. Peterson et al. (2014)

elaborate on the uncertainty in nature management; just like in the economy, it is difficult to know in advance what will happen. After this, it got warmer, there was no ice for migrating wolves, the wolf population went extinct due to inbreeding, and new wolves were introduced by humans.

Another example of how difficult it is to predict what will happen comes from Varaldskogen east of Kongsvinger, where Professor Per Wegge has followed capercaillie and black grouse populations since 1979 (Wegge & Rolstad, 2011). In the first six years, half of the forest area was selectively logged as old-growth forest, the rest clear-cut and young plantations. Reproduction followed small rodent cycles as expected. Then came sarcoptic mange, and for the next four years, the red fox population was greatly diminished, two rodent years followed one another, chick production was good and the adult population grew. Over the next 15 years, the red fox population rebounded, but at a lower level, and the microtine populations ceased to be cyclic; while the capercaillie population exhibited good chick production, adult mortality increased, likely due to increased predation from red foxes and goshawks. During the last seven years of the data series, most of the old natural forest had been cut and was being replaced by regenerating stands that had been thinned, allowing the bilberry understory to re-establish. While earlier research there had shown that capercaillie preferred older pine forests for leks, the researchers found new capercaillie leks were being formed in younger forest stands. Two consecutive microtine rodent peaks led to good chick production followed by consequent declines after the peaks. Poor reproduction was exacerbated by heavy rain and little insect food for chicks. The point is that Wegge could retrospectively divide driving forces and events into four distinct periods that could not be foreseen in advance. The effects of small rodents, foxes, goshawks and the weather varied, and capercaillie demonstrated greater flexibility in habitat choice than was previously thought. Complexity, change and chance.

Still, managers must decide whether to implement actions or not. Both can significantly impact the development of the relevant wildlife population. The challenge is that, just like in the economy, outcomes are not certain. Instead, many actions can yield more or less uncertain outcomes. This is where Aldo Leopold's definition of art comes in; one cannot know the outcome for sure and must choose actions under uncertainty. The challenge is to choose actions in a formal way that guides the transition from art to science.

According to Nobel laureate Kahneman (2012), humans have a strong ability to draw connections between observations. Heberlein (2012) shows how nature enthusiasts emphasize their own observations, with each hunting group often sitting in the cabin interpreting their observations and creating explanations for most things. When the story is good and the connections can plausibly be true, it is very easy to believe it. Many explanations can be correct, although many may not be. The challenge often lies in having many hypotheses but lacking the data to test them. And even if there is a lot of data, you might prefer to believe your own observation over a thousand scientific observations. However, the researcher should respect observations and be clear about what is certain and what is not. A friend of ours counted eight wolves from his car. He called a wolf researcher with his report and was told there were six wolves in that territory. Our friend, himself a naturalist, never reported wolf observations again, and he distrusts the reported wolf numbers.

Nature is diverse and complex, and observations and connections can be misinterpreted. Wildlife managers should be critical but also humble, as unexpected events can occur, and others' observations may be correct. For example, researchers and central authorities were wrong, and local managers were right, when there was significant disagreement regarding the number of reindeer on the Hardanger Plateau at the beginning of this millennium (Vaa, 2012b). This is an important learning point for wildlife managers—to be humble and to be open and willing to be challenged regarding assumptions and conclusions, as they may well be wrong.

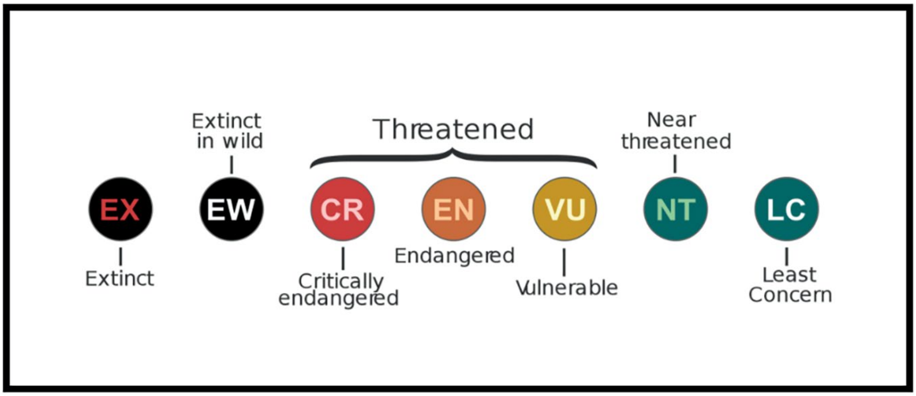
SYSTEM FOR SPECIES CLASSIFICATION AND SETTING GOALS

Goals can be set internationally, nationally, regionally and locally. The development of international conventions occurs after long-term collaborative efforts between governments and must be signed and ratified, often with country-specific exceptions, by participatory countries. National goals must also align with accepted conventions and are given in legislation and regulations.

In earlier times, people categorized animals into useful or harmful ones (Mykra et al., 2005). Today, we also classify animals based on entirely different criteria, which we will discuss. To have an overview and classify species in Norway, the Ministry of Education and Research (KD) established the Norwegian Biodiversity Information Center (Artsdatabanken)[1], which in 2018 became an independent, funded agency under the Ministry of Climate and Environment (KLD). The service is responsible for monitoring all wild species in Norway. They estimate there are over 72,190 species, of which 46,891 have been detected, described and named. Of these, individuals from approximately 500 bird, 92 mammal, five reptile and six amphibian species have been observed (Artsdatabanken, 2024). The attempts to keep track of the population trends of species and classify them according to criteria developed by the International Union for Conservation of Nature (IUCN) in the Red List categories:

1 https://artsdatabanken.no/Pages/135494/Norway_s_Species_Map_Service

Regionally Extinct (RE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Data Deficient (DD), or in the categories Least Concern (LC), Not Applicable, or Not Evaluated and thus not included in the Red List (Figure 8.1). Not Applicable means humans have contributed to the species coming to the country after 1800. Such organisms are classified on the invasive Alien List based on their potential harm to native species.



Peter Halasz, CC BY 2.5, via Wikimedia Commons

Figure 8.1: Overview of the categories in the Norwegian Red List[2].

In addition, the Norwegian Environment Agency classifies wildlife species as either huntable with hunting seasons or as protected (see hunting and trapping season regulations 2022[3]) based on population status, traditions and public attitudes. Many species are classified as least concern and protected, while some red-listed species can be huntable. Wild reindeer and mountain hares are on the Red List and are classified as game species with hunting seasons. Without hunting and large predators, wild reindeer populations would grow and consume their nutritional resources, and hunting is considered to have no impact on the development of mountain hare populations. Both of these species are vulnerable to the effects of climate change, however.

In accordance with ratified conventions, the overarching wildlife management goal is for Norway to preserve native species and limit the spread of alien species. Specific goals have been established for a few species. Through agreements, the Norwegian Parliament has set precise goals for the number of reproductive units of controversial large predators. Large carnivore boards and wild reindeer boards

2 https://www.fscbiodiversity.uk/blog/exploring-iucn-red-list-threatened-species

3 https://www.miljodirektoratet.no/globalassets/alle-tema/jakt-felling-og-fangst/jakt--og-fangsttider-2022-2028_a3.pdf (not available in English).

are tasked with managing to achieve goals set by the Norwegian Environment Agency. Municipalities, in collaboration with landowners and hunters, set goals for moose, red deer and roe deer populations. Municipalities can also choose to set management goals for local beaver populations. For other game species, those holding hunting rights can set their own goals.

Wildlife can be managed using different approaches (from Williams & Brown, 2014):

1. **Ad hoc management:** Based on anecdotal information, lacking clear management goals, with little technical basis for management actions, and with poor monitoring.
2. **Wait-and-see management:** Do nothing, assuming natural variation, and expect improvement. Avoid any management action and consequently learn little.
3. **Equilibrium management:** Managers guess what the correct equilibrium state is and manage toward this goal. No one knows the correct equilibrium, and little is learned.
4. **Traditional static management:** Goals and models are based on full knowledge of the system and what will happen with different management actions. Takes little account of uncertainty.
5. **Adaptive management:** A systematic approach for better resource management by learning from management results (see section below).

We perceive traditional static management as more directed toward achieving maximum sustainable yield (MSY). Such management is suitable when the system is very well understood. Adaptive management is best when environments are changing and there is uncertainty about systems and management outcomes.

ADAPTIVE MANAGEMENT

Managing livestock herds, where most factors are known and no significant changes are expected, is a relatively simple undertaking. The livestock owner can confidently determine which individuals should be slaughtered and which should survive, in order to achieve the greatest economic benefit given available forage. It is much more challenging with wild animals, where many factors are unknown—one often does not know how many animals are in the population, the quantity or quality of available forage, productivity, natural mortality, competition and/or predation from other species, or the optimal sex and age composition to harvest. In the face of great uncertainty, the USA has long used a formalized form of decision-making called

"Structured decision making." Adaptive management is one such form (Williams, 2011a; Organ et al., 2012a; Williams & Brown, 2014). Some authors have interpreted this concept somewhat differently (Williams & Brown, 2016).

The purpose of adaptive management is to learn while managing (Walters & Holling, 1990). Williams et al. (2007) define it as follows: "Adaptive management is a systematic approach for improving resource management by learning from management outcomes." Management is organized according to a formal system so that one can learn from the management and thereby adapt according to what is learned. The formal system distinguishes adaptive management from "trial and error" management. Adaptive management is seen as a process where management decisions are considered experimental treatments of the system—and the effects of these treatments are measured (Williams, 2015).

A hallmark of adaptive management is that the method is divided into two phases: 1) a thoughtful and argumentative planning phase and 2) a repetitive implementation phase (Figure 8.2). Williams and Brown (2014) and Williams (2011a) emphasize the importance of involving stakeholders or interest groups. It is important to agree upon common goals, but Williams (2012) shows that one can also experiment with different goals, using the adaptive management method, to find through experience what the best goal is.

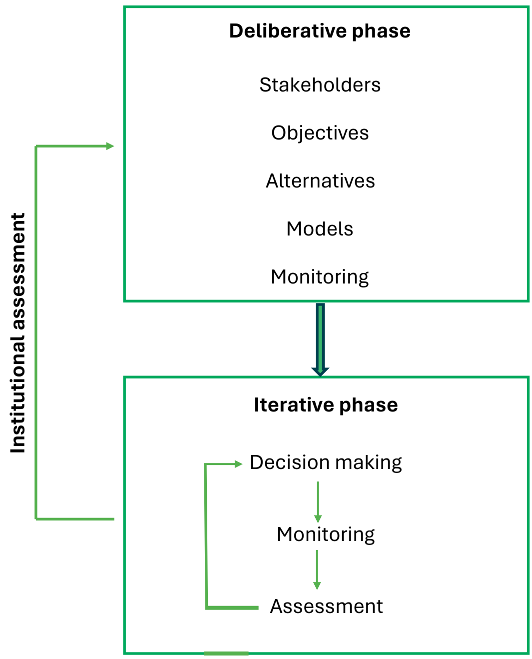


Figure 8.2: The process of adaptive management has two phases (redrawn from Williams and Brown, 2014, Figure 3).

A characteristic of adaptive management is that once stakeholders agree through deliberation on a common goal, the manager identifies alternative management actions and creates models to predict what will happen when these actions are implemented. There must also be agreement on a monitoring program—to determine whether the goal is being achieved. Only then can one proceed to the repetitive phase and implement the chosen management action. The outcome of the management action is monitored, and using the model, one evaluates whether it led to the desired result. Based on the evaluation, the management action can be adjusted.

A distinctive feature of adaptive management is the precise work with alternative, testable management models during the planning phase. The manager can choose to test one management model at a time or use different models simultaneously in various parts of the management area (Williams & Brown, 2014). Management can be active or passive. Active management aims to learn so that future management can be conducted with less uncertainty. In passive management, the focus is on management and resources, with the intention of managing as best as possible—and the learning gained is a bonus (Williams, 2011b).

The goal of adaptive management is to learn and reduce uncertainty in systems where it is difficult to predict outcomes in advance. Adaptive management strictly by the book is quite extensive and somewhat complicated. There are examples where it has worked well. This method has been used in managing the migratory mallard population migrating through mid-continental North America (Nichols et al., 2015). By testing different management actions and evaluating them against pre-established explanatory models over time, they concluded that a combination of spring population estimates and the number of ephemeral ponds in the breeding areas determines the hunting regulations they should recommend. By estimating population size and counting ponds, they can use the model to decide whether hunting should be closed or opened and whether any restrictions are needed (Figure 8.3). Williams and Brown (2014) provide American examples of adaptive management use from local to continental scale. In Chapters 12–15, we review several examples of practical management of different species. We perceive that Norwegian wildlife management often contains elements of adaptive management.

AUTHORS' REFLECTIONS

The future is easy to predict, but very difficult to get right. We believe much about management without truly knowing. Regardless, managers must decide whether an action should be taken and what it should be. By adopting a formal adaptive management approach with goals for actions and evaluation of their effects, we can gain knowledge about how these actions work in practice in different areas at different times. Fortunately, there are various monitoring programs that show what happens with different populations. This is usually passive monitoring without active management experiments. If more management was planned experimentally with different actions over time in different areas, we could learn a lot. Currently, we do not know the effect of protecting grouse at different densities. We manage moose without fully understanding the impact of many actions. Such things could be tested through collaboration and formal trials over larger areas in cooperation with research institutions.

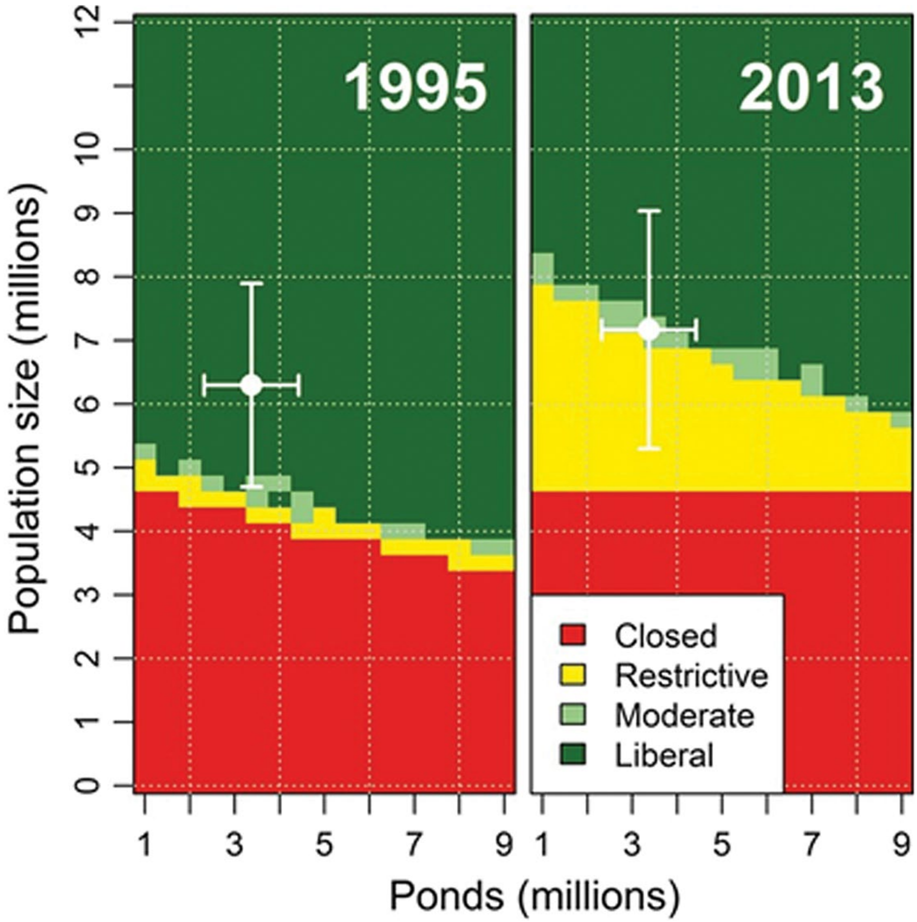


Figure 8.3: Model showing how a combination of mallard population size and the number of ponds in breeding areas can indicate how the population can be harvested. First, a model based on data from 1995—and subsequently how the model evolved after data collection until 2013 (from Nichols et al., 2015; Figure 2).

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9. Conservation of native wildlife species

Preserving biodiversity and ecological processes is the primary goal of the Norwegian Nature Diversity Act. Species and genetic diversity should be maintained in the long term, and species populations should be viable. Implementing measures to protect species is one of the most important tasks wildlife managers undertake. In this chapter, we will briefly highlight drivers of changes in nature before discussing the red-listed species Arctic fox, Eurasian eagle owl, and lesser white-fronted goose to explore the reasons they are on the Red List and the measures taken to remove them from it. Lastly, we will reflect on the conservation of wildlife and a marine mammal species.

DRIVERS OF CHANGE IN NATURE

The five drivers of changes in nature have been up until now, in descending importance, 1) changes in land and sea use, 2) direct exploitation of organisms, 3) climate change, 4) pollution and 5) invasive species (UN Report, 2019). Norwegian wildlife species may be threatened by one or more of these drivers. The Norwegian Biodiversity Information Center provides an overview of the status of species and classifies them based on the risk of extinction. To red-list a species, at least one of six minimum criteria must be met (see Artsdatabanken, 2021a). The Norwegian Biodiversity Information Center uses experts for extensive literature reviews and assessments of various species, categorizing them as viable or placing them in Red List categories: extinct, critically endangered, endangered, vulnerable (threatened categories) and near threatened or data deficient (also on the IUCN Red List, Figure 8.1). In 2021, 90 bird and 27 mammal species were on the Red List, with 62 birds and 17 mammals at risk of extinction. Among amphibians and reptiles, the moor frog is critically endangered, while the smooth snake (*Coronella austriaca*) and great crested newt are also on the Red List. The grey partridge, corn bunting (*Emberiza calandra*), crested lark (*Galerida cristata*), black rat and North Atlantic right whale (*Eubalaena glacialis*) are considered to be extinct in Norway (Artsdatabanken, 2021c).

ARCTIC FOX

The Arctic fox is adapted to extreme environments with low biodiversity in the Arctic and also occurs in alpine areas on the Scandinavian Peninsula (Figure 9.1). It is, along with humans, the only land-living mammal that arrived in Iceland on its own. In Norway, the Arctic fox was protected in 1930, but the population did not increase throughout the century. Linnell et al. (1999) reviewed potential reasons why the Arctic fox population did not increase:

1. Lack of carcasses due to the eradication of large predators.
2. Direct effects of climate change.
3. Interactions with the red fox.
4. Increased disturbance from humans.
5. Negative genetic effects from escaped farmed foxes.
6. Disease.
7. Inbreeding depression.
8. Critically small population size in a fragmented landscape.

After thorough discussion of the various hypotheses, Linnell et al. (1999) conclude that the most likely reason was that hunting had pushed the Arctic fox population below a critical size needed to maintain the immigration and emigration dynamics essential for long-term survival of local populations. The Arctic fox reproduced only during years with high small rodent populations, and during those years, the young had to disperse to find partners. Since very few litters were born, it was unlikely they would find a mate of the opposite sex. Since many foxes would die before the next small rodent peak, the authors believed the population was in a demographic trap, where growth was prevented by low density, leading to eventual extinction. Researchers did not rule out that climate and competition with the red fox could also play a role. However, Selås and Vik (2007) suggested that the decline in the Arctic fox population was due to the reduction of the wild reindeer population, resulting in fewer carcasses for Arctic fox food. As the wild reindeer populations grew, so did the red fox populations due to reduced fox hunting—and the Arctic fox succumbed to competition and predation.

Based on a report by Linnell et al. (1999), the Norwegian Environment Agency funded a breeding station for Arctic foxes in Oppdal (Landa et al., 2015). From 2006 to 2015, they released 303 Arctic fox cubs, and the fox returned to the mountains where it had disappeared, and the release program has been considered successful (Eide et al., 2015). However, in addition to the release of captive bred Arctic foxes, a feeding program was initiated. There were 81 feeding stations set up near dens in five mountain areas, each using an average of 90 kg of feed in winter and 40 kg in summer (Landa et al., 2015). In spite of this, the Arctic fox reproduced well only in years with plenty of microtine rodents (Angerbjörn et al., 2013). In some areas, intensive hunting of the competitor and predator, the red fox, was also initiated. On the Varanger Peninsula, the Arctic fox could not survive where there were red foxes. For Arctic foxes to thrive, red foxes must be removed (Hamel et al., 2013).

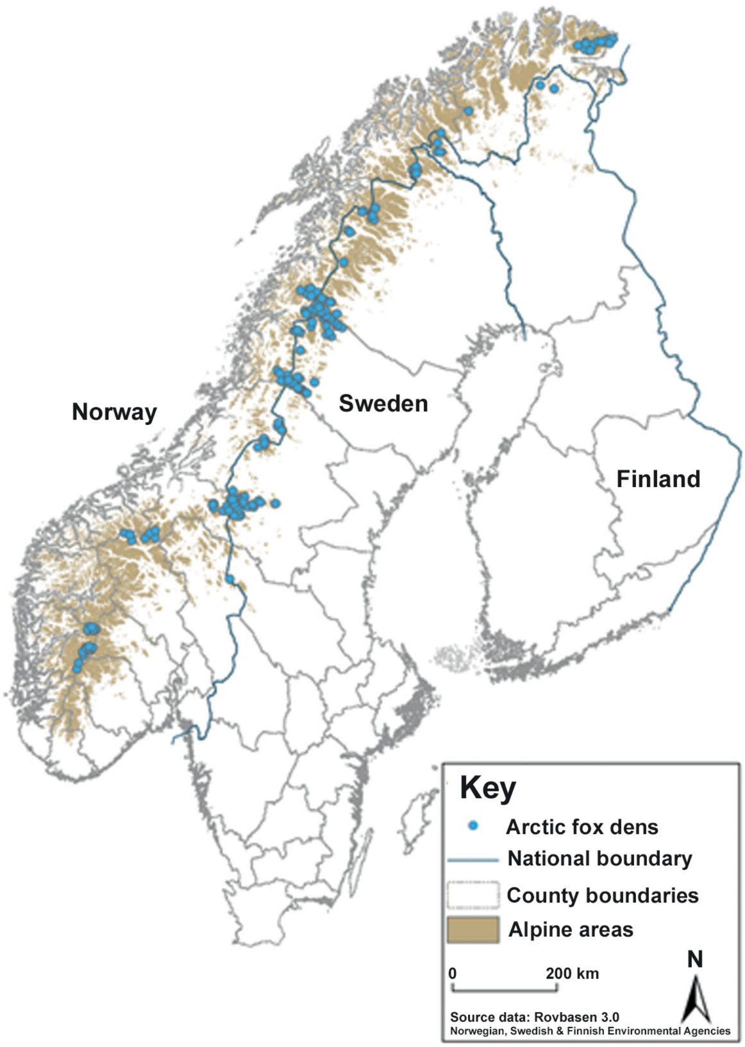

Figure 9.1: Registered Arctic fox dens in Norway, Sweden and Finland in 2022 (Eide et al., 2022). It is clear that the Nordic countries should collaborate on management. The blue dots are Arctic fox dens, and the brown areas are alpine areas.

Angerbjörn et al. (2013) investigated what influenced Arctic fox reproduction. Nearly half (47%) of the variation was explained by the presence of lemmings, winter feeding explained 29% and red fox control explained 20% of the variation. Eide et al. (2015) emphasized that these measures need to be comprehensive to have any effect.

It is complicated to understand why species struggle—and thus difficult to know what measures should be implemented. When populations are small, stochasticity also plays a significant role. If an adult Arctic fox was hit by a train, an important part of the adult population could disappear into a small, isolated population. The small Arctic fox population in Scandinavia is also inbred (Norén et al., 2016), which hindered population growth. The response from management, based on the best possible knowledge from research compiled in the Action Plan for Arctic Fox (Eide et al., 2017), was to increase basic feed through feeding stations, trap red foxes, breed and release Arctic foxes and start health monitoring programs and information campaigns (Eide et al., 2017). The measures have been extensive and the results satisfactory. A population of 40 to 60 individuals has increased to an average of at least 471 adult Arctic foxes in Scandinavia during 2019–2021 (Wallén et al., 2021). Various combinations of measures have been tested in different mountain areas, and over time we have gained much better knowledge about Arctic foxes and the mountain ecosystem.

Nevertheless, the future of the Arctic fox is uncertain. The success of the Arctic fox relies on captive breeding and releases, supplemental feeding, red fox control and lemming peaks. Although managers can continue with releases, feeding and red fox control, it is harder to do anything about lemming peaks. Global warming leads to warm periods during winter and icing along the ground, which means lemmings cannot reproduce under the snow, and subsequently populations do not cycle (Ims et al., 2011; Ehrich et al., 2020).

On the challenges for the Arctic fox, Pedersen et al. (2021a, p. 7) wrote:

> The climate changes that now overshadow all other drivers of the state of Arctic ecosystems cannot be managed at the ecosystem level. Because these ecosystems will be rapidly changing—perhaps toward entirely unknown states—it will be challenging to set achieva ble management goals.

And further (Pedersen et al., 2021a, p. 16):

> In Finnmark, the tundra ecosystem is losing typical Arctic species (Arctic fox and snowy owl), (as it transforms) from low-Arctic to boreal zones.

Research on Arctic foxes has nevertheless provided and continues to provide valuable knowledge about drivers and processes in the high mountain ecosystem. It seems clear that the best effort to preserve the Arctic fox in Norway is to counteract global warming. We can take comfort in the fact that the Arctic fox still thrives as a controlled pest in Iceland and as a fur-bearing animal in the lands surrounding the Arctic Ocean. In Alaska, they did so well that they were, after great effort, eradicated from islands in the Aleutians where they destroyed the original fauna after being introduced as free ranging furbearers (Ebbert, 2000). In Northwestern Alaska, on the Prudhoe Bay oil fields, human activity and food waste have enabled the rapid expansion of red foxes into the realm of the Arctic fox, to the detriment of the latter (Pamperin et al., 2006; Savory et al., 2014). Here in Norway, it is most likely that the Arctic fox will disappear if releases, feeding and red fox control cease.

EURASIAN EAGLE OWL

The Eurasian eagle owl population in Norway declined over a long period until it was protected in 1971. The population was so low that the World Wildlife Fund (WWF) released 602 captive-bred juvenile birds between 1978 and 1989 to improve the population. Fremming (1986) discussed several hypotheses for the long-term population decline and lack of recovery after protection:

1. **Hunting, trapping, nest raiding, predation, and disturbance:** He concluded that human activity could reduce populations, but depredation by humans or other animals could not be the cause of the population decline.
2. **Collisions with power lines and vehicles:** He found that eagle owls fared well in other countries with even more power lines and traffic than in Norway. Death by power lines could be significant if juvenile production was poor, but it could not by itself be the cause of the decline.
3. **Rat and crow poison:** Since much more poison is used in areas where eagle owls thrive, he concluded that this alone could not be the cause of the decline. He concluded that this could not be the cause in the inland areas of Eastern Norway, where the decline was greatest.
4. **Food scarcity:** Fremming shows that changes in agriculture and waste management have led to fewer voles and rats. Meanwhile, populations of forest grouse and hare have declined. His conclusion is that the decline was due to insufficient food availability.

He concludes that the eagle owl population in Eastern Norway became so low that it required enhanced food availability and immigration to recover.

The Directorate for Nature Management (Direktoratet for naturforvaltning, 2009b) also reviewed threats to the eagle owl:

1. **Power lines:** The main cause of death is electrocution when eagle owls perch on power line poles. Many also collide with power lines.
2. **Human interventions:** Eagle owls may abandon nesting sites due to nearby human activity. The Directorate mentions fish farming and wind turbines as causes. Logging near nesting sites can also cause eagle owls to stop using the area, although logging can also open up hunting areas.
3. **Prey availability:** The Directorate points out that American mink can decimate vole populations—that eagle owls survive well on the island of Lurøy where there are no mink but many voles. Many seabird species are important prey for eagle owls, and these have also declined where invasive mink occur.
4. **Overgrowth:** When open heathlands grow back, newly planted conifer forests can become too dense.
5. **Disturbances during the breeding season:** This is similar to point 2; various activities can cause eagle owls to abandon their breeding sites. Free-ranging sheep are said to disturb eagle owls during this period.
6. **Environmental toxins:** Eagle owls are at the top of the food chain and experience high concentrations of environmental toxins (Bernhoft et al., 2018).
7. **Hunting and wildlife crime:** These activities are not believed to have any significant impact today.
8. **Competition with white-tailed eagles:** White-tailed eagles kill eagle owl chicks, but this does not appear to be an important factor in the decline.

With so many possible reasons for the decline, it is difficult to prioritize those to be addressed, but the Directorate for Nature Management (Direktoratet for naturforvaltning, 2009b) considers preventing electrocution and collisions with power lines as the most important measures. Preventing human developments in known eagle owl localities through area planning is one measure, and preventing disturbances during the breeding season is another. It is suggested to restore hunting habitats and nesting sites. Shrubs and trees have already been removed from old nesting sites where eagle owls have subsequently returned. Providing the eagle owl with more prey by trapping the competitor mink, which can locally eradicate voles and other prey, is also mentioned. The report suggests that areas with many eagle owls today should receive national protection, but releasing eagle owls is not considered a viable option.

The eagle owl is a good example of how difficult it can be to promote a population. It is likely that several factors play a role simultaneously. Much indicates that Fremming (1986) was quite accurate, that the decline is largely due to reduced food availability for the eagle owl. There may be fewer voles because vole habitats have disappeared due to intensive agriculture practices and because mink prey on voles. Closed landfill sites lead to fewer available rats as prey. More pine martens and red foxes lead to fewer forest birds and hares. All of this is difficult to address. Few politicians would likely advocate increasing the rat population. On the other hand, a measure to prevent eagle owls from being electrocuted between power lines is a commendable project. Concrete physical changes can be made to the poles to make electrocution less likely. Once the physical measures are implemented, the project is complete and can be carried out within a certain timeframe. And no one can object to preventing the electrocution of a large, beautiful bird like the eagle owl.

The Stoltenberg II government allocated 30 million NOK for physical barriers on power lines to prevent eagle owls from being electrocuted (Regjeringen, 2011). It is likely that the limited amount of prey leads to eagle owls reproducing in fewer places and fewer chicks being recruited into the population. The simplest solution is to increase the survival of adults by measures such as preventing electrocution on power lines.

Eagle owl populations are monitored through studies (Husdal & Fjeldstad, 2019; Heggøy et al., 2020). Action plans should be updated as new knowledge is gathered, and insights are gained. A recent and exemplary Action Plan for Eagle Owl 2022–2026 (Miljødirektoratet, 2022a) summarizes eagle owl knowledge and provides guidelines for the future. Monitoring is enhanced by listening for territorial eagle owls with automatic sound boxes, and the plan continues and develops various measures. Enforcement and area protection are strengthened, electrocution and collisions are prevented, eagle owls are considered in area management planning, environmental toxins in eagle owls are monitored, preventing disturbance during the breeding season (including guidelines for tourism operators), prey availability should be ensured by preserving habitats and combating mink, overgrowth should be prevented in important hunting areas, and known nesting sites should be restored. After reading the various reports and articles, it is easy to think that the lack of suitable prey in sufficiently open hunting areas is the biggest challenge.

LESSER WHITE-FRONTED GOOSE

The lesser white-fronted goose was a common summer breeder in Fennoscandia until a significant population decline led to protection in Norway in 1970. Globally, the species is threatened, with a remnant of the Fennoscandian population occurring in Norwegian Finnmark (15–20 pairs) and otherwise a western Russian and an Eastern Russian population which decreased to 16,000–22,000 mature, reproducing birds during 2008–2017 (BirdLife International, 2024). Additionally, there is a Swedish population based on released birds from the western Russian population (Jones et al., 2008). There is relatively little genetic difference between the various populations (Øien & Aarvak, 2008).

Lesser white-fronted geese from Finnmark that do not successfully breed migrate eastward through Russia and Kazakhstan to wintering areas in Greece. Those that breed migrate along a western corridor to the same wintering areas (Figure 9.2).

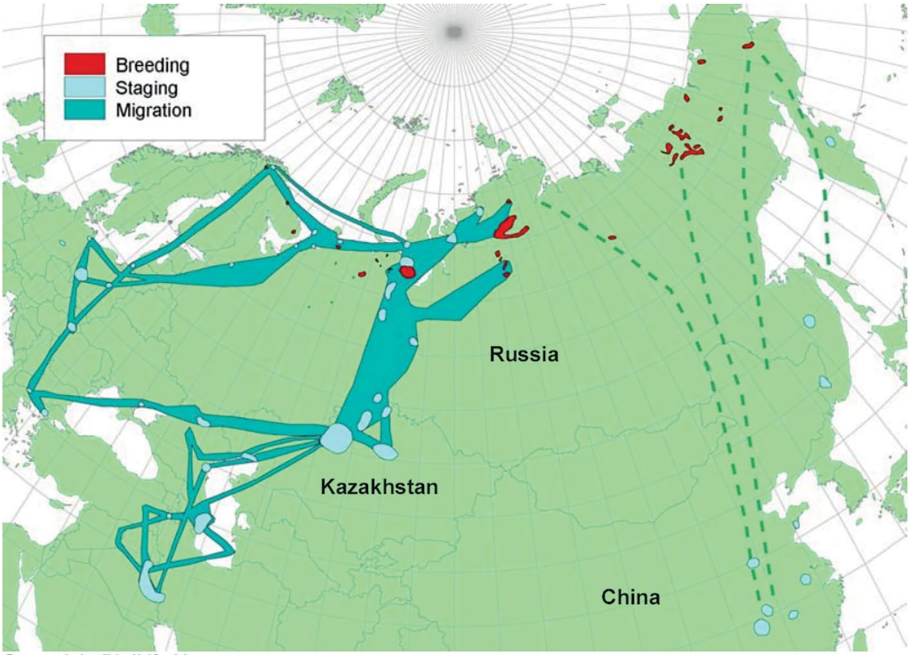

Figure 9.2: Global distribution of the lesser white-fronted goose during the period 2000–2005. Breeding areas are red, migration routes dark green and staging areas blue. Dotted lines show connections between breeding and wintering areas for the eastern population, but exact migration routes are unknown (Jones et al., 2008, Figure 1).

For non-ornithologists, it is challenging to distinguish from the common and widely hunted tundra bean goose (*Anser serrirostris*) that occurs within the range of the lesser white fronted goose. Geese are a resource hunted in Russia and Kazakhstan, but the lesser white-fronted goose is considered easier to shoot than other goose species, with a larger proportion being harvested. Hunting also occurs along the western migration route, but to a lesser extent (Øien & Aarvak, 2008).

The Norwegian Environment Agency has taken responsibility and has created an action plan with the goal of increasing the population from well below 100 to 1,000 individuals (Direktoratet for naturforvaltning, 2009a). Meanwhile, the Swedes have created their own action plan to restore the lesser white-fronted goose to Swedish mountains (Naturvårdsverket, 2011). Norwegians and Swedes have, as we shall see, chosen different strategies.

The Norwegian action plan for the lesser white-fronted goose (Direktoratet for naturforvaltning, 2009a) is based on an extensive review of knowledge (Øien & Aarvak, 2008) and outlines a number of threats and drivers that have reduced the population. The action plan has specific goals and measures in Norway and internationally. In Norway, in addition to information and monitoring, emphasis is placed on protecting breeding and staging sites. In breeding areas, attempts have been made to trap red foxes to prevent predation on eggs and chicks; measures have also been implemented at staging sites to counter predation. The measures seem to have resulted in positive population development (Aarvak et al., 2017). Goose-hunting rules have been changed to prevent accidental shootings. Hunting is prohibited where the lesser white-fronted goose typically is, and hunting of similar species can also be banned. Since loss and hunting in migration and wintering areas may be the most important reasons for the population decline, the plan places great emphasis on international conservation cooperation. For example, a dedicated position was used for international work for the lesser white-fronted goose in 2008 and 2009. Norway is to contribute financially to better monitoring along the original migration routes. Norway is also to maintain interest in the conservation of the lesser white-fronted goose through various forms of environmental cooperation, attitude-building work and political influence. The conservation of the lesser white-fronted goose is a good example of how complex and demanding it can be to protect threatened migratory birds. A recent evaluation of the Norwegian action plan by Kvalnes et al. (2023) highlights the need for continued international cooperation and monitoring and identifies knowledge gaps and possible measures, including controlling red fox populations and the need for a dialogue group with stakeholders in Norway, to improve understanding and cooperation in management.

The Swedes have chosen a different path (Naturvårdsverket, 2011), and Norwegian lesser white-fronted goose researchers see their approach as a threat (Ekker & Bø, 2017). The Swedes identified hunting in the wintering area as the problem. Therefore, they used barnacle geese (*Branta leucopsis*) with migrations to Western Europe as foster parents. Swedish lesser white-fronted geese are thus not killed by hunting in the winter areas. The first group of lesser white-fronted geese with a new migration route turned out to be mixed with greylag goose genes. When the mixing was discovered, the mixed individuals were replaced with pure lesser white-fronted geese from Russia, which now migrate southwest, and the westward migration is attempted to be maintained with the help of microlights. Jones et al. (2008) are critical of changing the migration routes of Fennoscandian lesser white-fronted geese. Willebrand and Willebrand (2018) have evaluated the Swedish release project. They note that internationally there are differing opinions on how lesser white-fronted goose populations should be reinforced. It is controversial to use foster parents of another species both because the young can be imprinted by the foster species and because the species themselves must find their migration routes. Nevertheless, they point out that the release of pure lesser white-fronted geese from Russia has gone well. They recommend control measures for red foxes in release areas and not releasing so many geese that they attract predators. They also recommend considering experimental releases together with barnacle geese to gain more knowledge.

We simply note that those who wish to protect species can have different opinions on what is right and wrong. Either one can be very pragmatic and accept changed migration routes and genes from Russia, or one can choose a more difficult path, changing the behavior of people in foreign countries and aiming for a pure, original population. Now, the Fennoscandian and Russian lesser white-fronted geese belong to the same species; the biggest challenge is whether the released geese hybridize with other species. Regardless, if the Swedes had not done anything, there would now be no lesser white-fronted goose in Sweden.

The lesser white-fronted goose is a good example of how we can conduct control of red fox populations and regulate hunting in Norway, but future population survival is difficult without actions outside national borders.

AUTHORS' REFLECTIONS

Here, we will reflect not only on the examples above but also on the value of protecting various red-listed species, the threat to wolves, the conservation of the harbor porpoise (*Phocoena phocoena*), why we implement measures to preserve the Arctic fox but not the partridge, how people perceive useful and harmful animals, and how species protection, fortunately, relies more on morality than on utility and harm.

From the examples above, we see that it can be very difficult to identify the underlying cause of a species being red-listed. Globally, the most common threat to wildlife species is habitat loss due to human activities (Pimm et al., 2014). But Arctic foxes likely became endangered due to competition and predation from red foxes, food scarcity in winter and irregular lemming cycles, all of which may be due, in part, to global warming. Global warming reduces Arctic fox habitat, and habitat loss and fragmentation have exacerbated the situation. The Eurasian eagle owl struggles likely because prey populations have decreased due to competition for prey with mink and red foxes. The lesser white-fronted goose may have initially experienced inadequate reproduction due to dense red fox populations in Norway but likely faces its greatest challenges outside our borders. The red fox is apparently a direct or indirect threat to Arctic foxes, eagle owls, and the lesser white-fronted geese and can be deemed a "climate winner" that is also favored by human activities on the landscape.

The threat to another endangered species, the wolf, is that a strong group of people do not want wolves, and a majority in the Norwegian Parliament wants very few wolves in Norway. Some of our wolves survive because a majority of Norwegians wants wolves (Krange et al., 2017) and because wolves born in the much larger Swedish population are immigrating to Norway. Wolves are critically endangered in Norway due to parliamentary decisions to keep the population as low as possible given international obligations and political considerations.

Marine mammals are not, by Norwegian definition, considered wildlife by legal definition. However, harbor porpoises can exemplify how simple measures could have significant positive impacts—even if they are not implemented. In Norway, from 2006 to 2008, around 7,000 harbor porpoises drowned annually in cod and monkfish nets. This could be significantly reduced if nets were not set shallower than 50 meters and if acoustic deterrents were mandated on the nets. These are small devices that emit sounds that scare away porpoises (Bjørge et al., 2013). Despite this knowledge, it has not yet been incorporated into Norwegian regulations. It is easy to get the impression that industry and legislators are more focused on profit than on the drowning of porpoises.

The reasons for species being on the Red List can vary. Some are relatively new immigrants, some live on the edge of their distribution area and others have been here for a long time. The first nest of the collared dove (*Streptopelia decaocto*) was found in Norway in 1955. Haftorn (1971) shows how quickly the collared dove spread from India, through Europe, and into Norway. Now, the collared dove is near threatened in Norway, likely due to changes in agriculture leading to less winter forage. Haftorn (1971) also notes that subspecies of the black-tailed godwit were rare visitors from their usual distributional range. The black-tailed godwit is now listed as critically endangered because two immigrant subspecies have begun breeding sparsely in certain coastal areas and struggle to raise young here.

The Eurasian eagle owl is also critically endangered because it has disappeared from traditional nesting sites. The owl is a symbol of wisdom. In the author Storaas's childhood, stuffed eagle owls were in most Norwegian schoolhouses. Today, this rare species is protected and persists in small, scattered populations. The collared dove is a recent immigrant that has increased in numbers over time but has somewhat declined recently. The black-tailed godwit is rare in Norway because it has been at the edge of its range. All these species are, according to definitions, on the Red List; we decide on these definitions and can debate which species might be most important to preserve.

The partridge is considered extinct in Norway. Partridges are used by bird dog enthusiasts to train hunting dogs. Some controversial releases have been such that the birds could not survive long. Therefore, the Environment Agency banned such releases. In 2022, bird dog clubs applied to improve living conditions for partridges in the cultural landscape and release partridges in ways that allow them to survive. So far, they have not been heard. The Arctic fox, considered a species of special responsibility in Norway, has survived due to supplemental feeding, red fox control and reintroductions through the captive breeding program. To bring back extinct partridges requires habitat measures, the production of forage plants, as well as reintroductions, supplemental feeding and red fox control just like for the Arctic fox. The Environment Agency believes the situation for partridges and Arctic foxes cannot be compared. It seems that it is fine to take action before a species is extinct, but after a species is extinct, the same measures cannot be implemented here in Norway. Both Arctic foxes and partridges are on the edge of their distribution area in Norway, and if we cannot stop global warming, partridges will probably return as conditions improve and the Arctic fox will disappear as conditions deteriorate, regardless of our priorities.

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10. Invasive species

Invasive organisms are the fifth strongest driver of changes in nature (UN, 2019). They can pose a significant threat to native species. Invasive species must be managed based on the phase of invasion and the biology of the species. Here, we will first discuss threats from invasive species and point out how the phase of invasion determines the appropriate measures. Then, we will discuss three examples of managing invasive species in Norway to show how the threat can be addressed. The population of American mink is saturated, raccoon dogs rarely reach Norway due to intensive control in Sweden, while wild boar, which was reintroduced but is now considered native in Sweden, is managed as an invasive species when they cross into Norway on their own. We will question whether wild boar is truly an invasive species. Finally, we will reflect on the phenomenon of invasive species in terms of wildlife management.

THREATS AND MANAGEMENT

Species adapted to a certain ecosystem will generally be at a disadvantage due to competition of predation when they enter a completely different ecosystem. Of the 1,473 invasive species assessed by the Norwegian Biodiversity Information Center (Artsdatabanken, 2018a), there is a high or very high risk for 233 of them to threaten biodiversity in Norway. The consequences can be catastrophic. A classic example is the catastrophic introduction of European rabbits to Australia by the English for hunting purposes. The rabbits spread quickly and became the worst pest in Australia (Fenner, 2010). When foxes were introduced to control rabbit populations, they caused irreparable damage to native species (Fleming et al., 2021). A more local example is found in Norway, where the American mink spread from mink farms and has destroyed many seabird colonies (Bevanger & Henriksen, 1995).

The Norwegian government wisely developed the plan "Combating Harmful Invasive Organisms. Action Plan 2020–2025"[1]. Action plans are created against various harmful invasive organisms. It states that the most cost-effective measure is to prevent invasion in the first place. If invasion is not preventable, it is important

1 https://www.regjeringen.no/contentassets/f1c4ed10cef245edac260a0c5ba329fe/t-1570-b.pdf

to address invasive species immediately upon detection, in the proactive phase before they become numerous (Figure 10.1). It is easier to find and eliminate a few animals before the active phase when an invasive species has begun to reproduce and spread because eradication requires intensive effort. When an invasive species has spread to suitable habitats throughout the country, we have reached the reactive phase. Then the goal is the management and control of local populations, and eradication is highly unlikely.

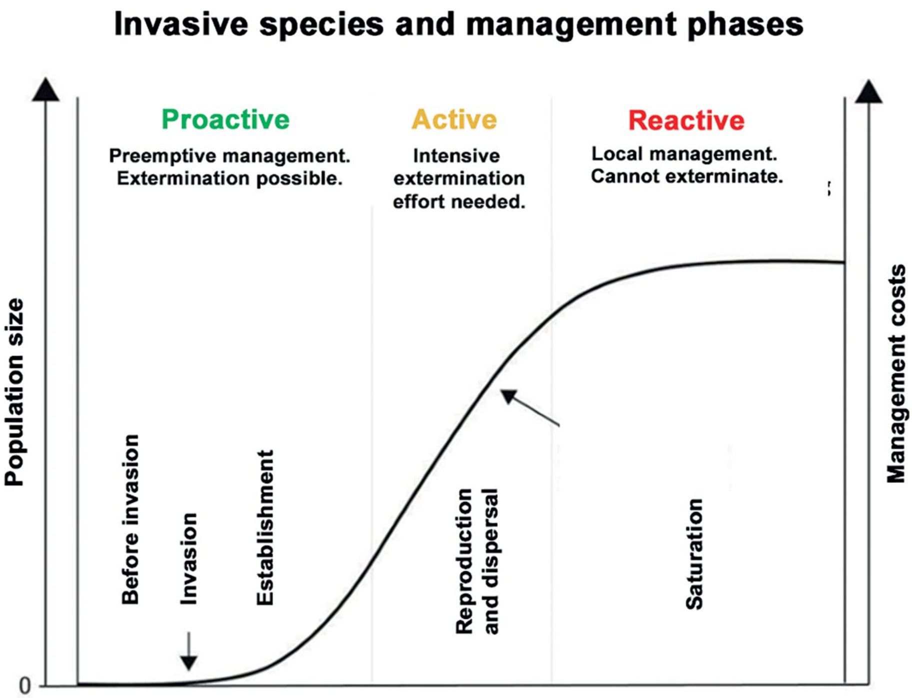

Figure 10.1: Schematic representation of different spread phases of an invasive harmful species in relation to control costs in the various phases. Only in early phases is eradication or prevention of establishment generally possible (adapted from Florida Invasive Species Partnership (FISP): http://www.floridainvasives.org/).

AMERICAN MINK

The American mink primarily inhabits wetlands and areas near water. Male mink weighs around 1 kg, while females often weigh slightly more than half of that. Females reproduce their first spring and can have up to eight offspring. The American mink was brought across the ocean to European fur farms. Mink escaped, and in Britain, they have nearly eradicated the water vole (*Arvicola amphibius*) through predation (Barreto et al., 1998), and in Eastern Europe, the European mink (*Mustela lutreola*) through interspecific competition (Macdonald & Harrington, 2003). In Finland, American mink have decimated the water vole population, which has resulted in less grazing and vegetation encroachment on mink-inhabited islands (Fey et al., 2009). In contrast, the active removal of American mink has led to higher survival of nests of small and medium-sized ground-nesting birds on islands (Nordström et al., 2002; Nordström & Korpimaki, 2004; Nordström et al., 2004). Frog populations have also increased where American mink have been removed (Salo et al., 2010).

In Norway, American mink escaped from mink farms (Bevanger & Henriksen, 1995) to where they have found it livable, and populations are connected with Swedish, Finnish and Russian populations. The population is now well established in the reactive phase, and it is neither practical nor economically feasible to remove it. The has blacklisted the American mink and considers it a significant threat to Norwegian nature. A nationwide action plan (Direktoratet for naturforvaltning, 2011) for combating the American mink was implemented with the following goals:

1. Remove or reduce the mink population in prioritized protected areas to fulfill conservation objectives.
2. Remove or reduce the mink population in prioritized habitats for red-listed species outside protected areas.
3. Facilitate local initiatives to succeed in removing/reducing the mink population in habitats for important species for harvesting, other industries, and nature experiences.
4. Create a better knowledge platform for measures against mink and for work against novel and harmful invasive species that become established.

In this plan, we see that the Norwegian Environment Agency wisely prioritizes efforts where it is most important based on conservation objectives—and where results from these measures can be expected. The plan also includes information about mink and mink trapping—so that the public is aware that mink causes harm and that the harm can be reduced through hunting and trapping. Research will largely focus on gaining knowledge to more easily prevent mink from harming other species.

Many have discussed the use of contraceptives to control populations (Massei & Cowan, 2014; Asa & Moresco, 2019). For small, r-selected and widely distributed species like mink where contraceptives would need to be delivered via bait, this seems imprecise and ineffective. The chosen measure is culling since it is more cost-effective.

The action plan emphasizes collaboration between public authorities, landowners and hunters and stresses the rules that must be followed. The hunting rights, including those for mink, belong to the landowner, and removal must be conducted according to regulations. Authorities can remove mink in certain areas, but it will be more effective if private individuals also remove mink.

The action plan includes appendices describing how successful mink control can be organized. In summary, managers should:

- Choose an isolated island, previously important as a bird nesting area, preferably far from land (>2 km) and with strong sea currents.
- Survey the area with trained mink dogs before the birds start nesting, preferably multiple times.
- Since mink can use many islands and islets, survey all nearby islets and islands on the same day.
- If the dog cannot flush out the mink when located, using a leaf blower into the hole can drive it out.
- The mink must be culled by shooting; it should not be killed by the dog.

Employees of the Norwegian Nature Inspectorate have had great success with this method and have removed mink from many nesting areas. However, as usual, it is difficult to demonstrate the impact of the removal since this was planned as a management measure and not as a research project (Stien et al., 2023).

Salo et al. (2008) have shown that mink are less likely to swim when white-tailed eagles are nearby, as white-tailed eagles often take swimming mink. Otters are also known to take mink. Otters and white-tailed eagles can thus help keep smaller islands mink-free, but otters and white-tailed eagles can also harm seabird colonies. Mink is a good example of an invasive species in the reactive phase where the goal is to limit harm in restricted areas.

RACCOON DOG

The raccoon dog was introduced to the western parts of the Soviet Union as a fur animal and by the 1990s had established itself in Finland and parts of Europe (Kauhala, 1996). However, the population in Norway and Sweden is still in the proactive phase. The raccoon dog lives monogamously in pairs and is an omnivore that prefers areas in or near wetlands and cultural landscapes. It hibernates and needs to store enough food to survive the winter—the length of winter thus sets the northern limit for survival. It eats insects, birds, some plants, small mammals, amphibians and carrion—anything edible it comes across. Raccoon dogs are a threat to amphibians and the eggs and chicks of ground-nesting birds. The Norwegian Environment Agency invests heavily in preventing it from entering the country, with the most important effort being to support work against the establishment of raccoon dogs in Sweden.

The Swedes initiated the Swedish Raccoon Dog Project to prevent the raccoon dog from establishing in Sweden (Dahl et al., 2016). The project is an interesting example of how to prevent a species from establishing itself and contains several elements:

1. **Education and dissemination of results:** The project considers it important to inform and make the public aware of the damage raccoon dogs cause, identifying characteristics and what people should do if they see a raccoon dog.
2. **Collaboration with the public and hunters:** The project has established a tip line and its own website with information. Collaboration with the Swedish Association for Hunting and Wildlife Management regarding raccoon dog education, hunting and reporting.
3. **Continuous management:** Ongoing hunting with dogs, trapping and monitoring with wildlife cameras. Wildlife cameras at strategically important locations transmit raccoon dog images directly to the mobile phones of project employees, who immediately respond. There is a story about a tracker who left his own wedding when he received a message about a raccoon dog. They capture, sterilize and radio-tag one of the animals in a pair and cull the other. Afterwards, the tagged animal (the Judas animal) searches for a new mate over large areas. When it finds a mate, it settles, which can be seen from the positions the transmitter sends to the project via the mobile phone network. The new mate can become the new Judas animal, and the old one can be culled.

In Norway, raccoon dogs can be hunted year-round, but they hibernate in winter. Their tracks are very similar to those of red foxes and are difficult to distinguish. Raccoon dogs can be shot over bait, and new regulations allow shooting raccoon dogs over bait with artificial light mounted on walls, as with foxes. Fortunately, a raccoon dog can lie down and play dead when chased by dogs, making it easier to capture. Author Brainerd participated in research captures in Finland with researcher Kaarina Kauhala in the 1990s. They were able to catch raccoon dogs by using specially trained dogs at night without snow cover. When the research dog found the raccoon dog, it played dead. Researchers could then handle and radio-instrument the animal without the need for drugs.

The Swedish Raccoon Dog Project has been a success. As long as the Swedes continue their project, few raccoon dogs will reach Norway. The best Norwegian measure would be to support the Swedish effort.

WILD BOAR

Wild boar is a particularly interesting non-native species because it was originally part of the Norwegian fauna. Bones from wild boar have been found at the dwelling sites of Stone Age Norwegians (Hjelle et al., 2006). After some time, wild boar bones were replaced by bones from domestic pigs. How long wild boar or hybrids between wild boar and domestic pigs survived is unknown, but the wild boar had disappeared by the year 1000, and probably earlier (Rosvold et al., 2010). We can speculate on why the wild boar disappeared. During the cold period leading up to the year 500, potential habitats with richer deciduous forests in Norway may have been limited. When competition arose between wild and domestic pigs, it may have become important to kill the wild ones. As humans began to clear forests, and as colder weather and some particularly snowy winters set in, it may have become easier to eradicate them. In Sweden, with larger expanses of temperate broad-leaved forests, the wild boar managed to survive until the late 1600s.

Wild boar populations have a much greater potential for population growth than cervids. Red deer and reindeer typically produce single calves. Well-fed, fully grown moose cows can have twin calves, very rarely triplets, and roe deer can under good nutritional conditions have three fawns. In contrast, the wild boar sow becomes sexually mature at just 10 months old and with litters of three to eight piglets. The wild boar is r-selected compared to cervids, making it almost remarkable that Norwegians and Swedes managed to eradicate such a prolific species at the time. But back then, all hunting and trapping methods could be used.

In 1976, wild boar were released into Swedish reserves as a game species, but captive animals have also escaped from farms in Sweden (Welander, 2000). Marked wild boar piglets spread on average 16.6 km (males) and 4.5 km (females) from their birthplace (Truvé & Lemel, 2003). Additionally, hunters are said to have translocated wild boar to establish new populations, although there is no completely certain documentation of this. Today, there are dense wild boar populations in Sweden. They have steadily increased, and during the hunting season of 2020–2021, over 160,000 were harvested (Jägareförbundet, 2022). The next year, harvest decreased to around 120,000, possibly due to more effective hunting with thermal sights, cold and wet spring winters, or disease. There are many wild boar populations near the Norwegian border, and viable populations with breeding have been established in the municipalities of Aremark, Halden and Trøgstad in Østfold, with scattered observations in Østfold, Akershus and Hedmark. The Norwegian Biodiversity Information Center considers the risk of wild boar establishing themselves in Norway to be high (Artsdatabanken, 2018b). The wild boar is in the proactive phase in Norway.

Wild boar was present in Norway during the Stone Age. Nonetheless, according to the criteria used by the Norwegian Biodiversity Information Center, the wild boar is considered a non-native species with a high risk of ecological damage. The Center (Artsdatabanken, 2012) emphasizes experiences from Sweden, where wild boars damage agricultural land, gardens and recreational areas, cause traffic accidents, and can be carriers of many diseases. Particularly, the pig farming industry fears that wild boar could infect domestic pigs with African swine fever. Rolandsen et al. (2023) assess the damage effects as less significant than previously thought in 2012.

A Management Plan for Wild Boar 2020–2024 has been developed (Miljødirektoratet og Mattilsynet, 2019). The goal of the plan is to have as few wild boars as possible in the smallest possible area. Measures and tools against the wild boars are summarized, with comments on legal and economic consequences. The key elements are population monitoring, cooperation with landowners, various measures to facilitate hunting and prevent feeding access, informational efforts, and fencing to prevent contact between wild and domestic pigs. These are extensive measures aimed at preventing a formerly native Scandinavian species (likely exterminated by humans) from reestablishing itself now as an invasive species from a neighboring country that has reintroduced it but deems it now as native.

AUTHORS' REFLECTIONS

The American mink is an example of how difficult it is to eradicate a harmful non-native species once a population has reached the reactive phase of management. Sweden is trying to prevent the immigration of raccoon dogs, and Norway is attempting to prevent the immigration of wild boar in the proactive phase. The regulations for immigrating species are clear, and the listing and measures against non-native species are well-founded. Nonetheless, we reflect on whether all species that come here on their own should be welcomed and whether all introduced species are harmful. Some Eurasian species might well have adapted to Norwegian conditions after the ice receded but never found their way here for various possible reasons. We reflect on invasive species and whether wild boar is truly a non-native species or if concerns regarding disease and crop damage are at the heart of its classification as undesirable in Norway.

Introduced species can pose a significant threat to native Norwegian species. But even species that arrive without human assistance can cause great harm. The golden jackal naturally immigrated to Northern Norway (Finnmark) and is thus entitled to protection according to the regulations even though the initial official reaction was that it should be eradicated. We do not know how the golden jackal will affect the red fox, reindeer calves, lambs or small game. If the raccoon dog had made its way from East Asia on its own, would we have had to welcome it according to the regulations? The deer ked flies north on its own wings and thus belongs in Norwegian nature, but it is a great nuisance to moose and humans. The muskox was eradicated in Europe by humans after the ice age but was reintroduced by humans in the 20th century, yet it now is a symbol of Dovrefjell, a mountain central in Norwegian cultural tradition dating back to the oath made at the Constitutional Convention in 1814, "United and loyal until Dovre falls." New species can be beneficial or troublesome for native wildlife species. For example, partridges from Europe and pheasants from Asia are prized game by upland bird hunters in North America.

In North America, mountain ranges run north-south, allowing wild sheep and wild goats to move northward in the mountains as the ice melts. In Europe, lowlands separate the southern mountains from those in the north. If they had found their way, chamois, ibex and mouflon could likely utilize the pastures now used by human-introduced sheep. The wild boar is particularly interesting. When a species defined as native in Sweden crosses the border to Norway on its own, it is considered a non-native species with a high risk of impacting biodiversity. It seems just as easy, based on history and ecological circumstances, to argue, like the Swedish Parliament, that the wild boar is native as it is to argue that it is not. Many Swedish hunters highly value wild boar and wild boar hunting. They can hunt wild boar all year round without fear of extinction. Many Norwegians travel abroad to hunt wild boar. Wild boar is a fantastic game species that tastes good and can be hunted all year with the landowner's blessing. However, the agricultural industry, especially the pig farming industry, fears significant losses if wild boar and possibly African swine fever arrive in Norway, and economics plays an important role in policy formation. We perceive that the biggest problem with wild boar in Sweden is that landowners and hunting rights holders, who often lease farmland to farmers, want many wild boars on their land and feed very dense populations. The hunting rights holder harvests many wild boars on their hunts, while farmers suffer significant crop damage on leased and owned land. A ban on feeding and free hunting on cultivated land would help farmers who bear the costs.

Species that arrive in Norway without human assistance (and thus are not considered to be invasive) can also have a significant negative impact on native species. Golden jackals and other southern species are now arriving in Norway due to the effects of human-induced global warming. Perhaps we must say that the golden jackal arrived in Norway with human assistance and therefore should be on the non-native list? Nature is changing, and the categories we place species in often depend on how we define those categories and, as with the wild boar, economic costs vs. benefits.

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11. Population exploitation and management

Aldo Leopold (1933) wrote that the goal of wildlife management was to enable landscapes to produce consistent annual yields of wild game for the recreational purpose of hunting. In our time, the goal is much broader, but sustainable harvesting remains essential. This and the following three chapters focus on harvesting. Various forms of animal killing are a necessary component of human life on Earth (Allen et al., 2023), and direct exploitation of organisms is considered the second strongest driver of changes in nature (UN, 2019). Therefore, it is important to find forms of exploitation that do not harm wildlife resources. We will first discuss different forms of wildlife utilization and determine whether hunting poses any threat to wildlife, before presenting regulations for hunting and trapping in Norway. Finally, we will explore how hunting quotas can be regulated.

POPULATION EFFECTS OF HARVESTING

A comprehensive review of global population development data showed a greater decline in harvested populations compared to non-harvested ones, but managed populations with regulated harvesting have increased (McRae et al., 2022). When examining the impact of harvesting on wildlife, it is essential to distinguish between different forms of animal killing:

1. **Unregulated harvesting:** Lacks knowledge, regulations, or enforcement of rules. Can be unethical and inhumane.
2. **Regulated harvest:** Regulated recreational hunting or trapping of surplus, aims to preserve the population. Ethics and animal welfare are important components.
3. **Culling:** Aims to keep the population down, agricultural ethics. Emphasis on efficient removal.
4. **Poaching:** Illicit and illegal take without regard to laws, ethics or animal welfare.

We will review these four activities and assess how they affect wildlife populations.

Unregulated harvest

In the book *Collapse*, Jared Diamond (2013) provides several examples of people destroying the natural environments they depend on. He speculates about the thoughts of the person who cut down the last tree on Easter Island (Diamond, 2013, p. 117). It is common to think that if one does not harvest the resource now, someone else will tomorrow. Someone may also say that they need the resource now for survival without regard for the future. Hardin (1968) wrote about the tragedy of the commons, where selfish, unregulated use of free, public resources will lead to overexploitation. Our history of whaling and fishing is full of examples where someone found a new way to exploit an unregulated common resource, often resulting in the resource disappearing, to the benefit of future wealthy heirs. For instance, Norwegian billionaire Kjell Inge Røkke's fortune is based on exploiting an Alaskan pollock population (*Theragra chalcogramma*) by exploiting loopholes in regulations (Stavrum, 2013).

Baskin (2016) concludes, after studying a 300-year series of hunting statistics from Russia, that hunting must be regulated for moose to survive. Hardin (1968) argued that resources should be privatized or subjected to national or international regulations to avoid destruction. Elinor Ostrom (1990) challenged this and won the Nobel Prize in Economics for showing that local communities could sustainably manage common resources without intervention from central authorities or privatization. Everyone seems to agree that regulations are necessary to preserve resources.

Large relatively long-lived K-selected animals with slow reproduction rates and high commercial value are most vulnerable to extinction through unregulated harvesting. Without strict regulations, whales, elephants and rhinos would have been driven to extinction to a much higher extent. In Norway, brown bears were eradicated, and both moose and wild reindeer have been periodically protected to prevent extinction. The pine marten reproduces slowly for its size, but its fur and bounty rewards offered high daily wages compared to regular work in the early 20th century (Tillhagen, 1987). Consequently, hunting pressure was so high that it disappeared from most of Norway and Sweden when it was protected in 1930 in both countries (Helldin, 2000).

The red fox is much more r-selected compared to the pine marten. Despite valuable fur and bounties, it has survived through cunning and adaptability, a varied diet, rapid reproduction, and excellent dispersal ability. Biology saves the red fox; it requires a significant effort to reduce its population over a larger area compared to the pine marten, which is more easily harvested and more vulnerable to overexploitation. The main rule is that fast, r-selected small game species can be harvested without quotas during the hunting season, while valuable, slower K-selected species must be harvested more carefully and precisely with regulations to avoid significant depletion or extinction.

Regulated harvest

In ethical hunting, game should have a chance to escape while being hunted; "fair chase" is the terminology used in English-speaking countries, but there is no direct equivalent for this phrase in Norwegian. The Biodiversity Act states that the hunter should harvest from a surplus, and the goal is to preserve the population in the long term. Hunting affects populations by removing healthy, vital individuals. The removal of individuals significantly impacts when the population is low but has little effect when the population is near its carrying capacity, K, as harvesting then leads to increased production and population.

The impact of harvesting specific individuals is significant. Milner et al. (2007) examined the literature on the effects of skewed sex ratios and selective harvesting of trophy animals on population growth rates. They found, unsurprisingly, that population growth for polygamous species increased when there was a higher proportion of females and a lower proportion of males in the population. However, growth rates also decreased when there were too few large males and mostly young males in the population. Harvesting old females can lead to a loss of habitat knowledge within a group. Removing dominant males can, in some systems, result in young incoming males killing the offspring of the older males so that the females will mate again, such as with brown bears (LeClerc et al., 1997). Hunting can have many different effects.

Selective harvesting of trophy animals can also lead to genetic selection for males with smaller antlers or horns, as they get the chance to mate since the largest are shot. Monteith et al. (2013) investigated whether the size of recorded trophies of American big game had changed over time. They concluded that the size had decreased, but the reduction was so small that it was likely negligible. LaSharr et al. (2019) studied this in more detail for bighorn sheep and found that the size of sheep horns had decreased, but the reduction was not due to genetic changes. The trophies were smaller because the sheep harvested were younger.

Norwegians observed that unregulated harvesting could lead to the disappearance of deer species, while small game managed to survive well. Therefore, detailed regulations have been common for slow K-selected big game, while landowners have had free hunting rights within defined hunting seasons for fast r-selected small game.

Culling

Culling aims to do the opposite of harvesting; it seeks to reduce or remove a wildlife population that humans have introduced to new areas, but also to reduce populations of species native to the area when recreational hunting effort is inadequate. It is easier to remove species from small areas, especially isolated islands, but more challenging in larger, contiguous land areas (Robertson et al., 2017). Large, slow K-selected species are much easier to control than small, fast r-selected species. Once a small, fast species has established and adapted over large, contiguous areas, it is usually practically impossible to completely eradicate the species.

Culling has the most impact when populations are at their lowest just before breeding. For non-native mammal species like wild boar and mink, eradication is permitted even during the breeding season, although female wild boars cannot be culled until their piglets are dead. Culling employs agricultural ethics, and the Norwegian Nature Inspectorate (SNO) is allowed to use methods not permitted in hunting. They use helicopters and snowmobiles, locate dens, dig out wolverine cubs and euthanize them on government orders. Culling of certain species, such as wolves, can be carried out by volunteer hunting teams and is easiest with tracking snow.

Poaching

Poaching is a criminal act and not hunting. In the book "*Krybskytteri i det Sydlige Norge*" (Poaching in southern Norway), the author under the pseudonym Gravenstein (1922) remarked that legal hunting was dull; it was much more exciting when he had to outsmart both the game and the owner of the hunting rights. The anonymous author undoubtedly perceived poaching as hunting. However, poaching is theft and complicates management because it causes the manager to lose oversight of the population situation. Poaching is particularly harmful to populations of slow K-selected species like rhinos. Poaching a common, fast r-selected small bird, on the other hand, would not have any significant impact on the bird population.

The reasons for poaching can range from simple subsistence to organized theft for the illegal sale of meat or coveted body parts like rhino horns and ivory. Where there is illegal trade in wildlife and wildlife parts, it has serious consequences for wildlife populations and local communities ('t Sas-Rolfes et al., 2019). Delpech et al. (2021) reviewed the available literature on the topic and stated that it is difficult to determine precisely which measures are most effective against poaching, but they highlight the importance of community involvement and oversight. Large, slow species that offer significant rewards for poachers are, of course, most at risk of extinction.

In Norway, poaching does not seem to be a widespread problem. No one needs to poach for food. Nevertheless, several court cases in recent decades have revealed poaching of big game in order to sell the meat. Several verdicts have also documented the poaching of predators. Convicted poachers have often shot wolves not for economic reasons, but because wolf protection challenges their identity and values. The Norwegian Hunters and Fishermen's Association (NJFF) strongly opposes poaching, as it can erode the trust society has in hunters.

REGULATIONS FOR HUNTING AND TRAPPING IN NORWAY

During the regulatory period 2022–2028, Norway allows hunting and/or trapping of 27 birds, one hare species, two rodents, five predators (including lynx), four cervids and 16 introduced species (Hunting and Trapping Regulations, 2022). The Predator Regulations (2005) set rules for licensed culling and quota hunting of the four major predator species. It may also permit the culling of golden eagles that cause damage.

Game species that can be hunted are divided into small game and big game. Big game in Norway includes moose, red deer, fallow deer, wild reindeer, roe deer, wild boar, mouflon, musk ox, bear, wolf, wolverine and lynx (Hunting Regulations, 2022). Big game can be categorized into three groups: 1) native hoofed species, such as moose, red deer, wild reindeer and roe deer; 2) imported hoofed species, including fallow deer, wild boar, mouflon and muskox; and 3) predators, including bear, wolf, wolverine and lynx. Species not classified as big game are considered small game. Harvesting of big game species is typically governed by plans and precise quotas approved by higher authorities, while small game harvesting is regulated by hunting seasons and any restrictions set by the owner of the hunting rights. Authorities have developed a strategy for cervid management (Directorate for Nature Management, 2009c). This strategy references several key documents and aligns with the Biodiversity Act and Wildlife Act, which are further promoted through the Cervid Regulations (Miljødirektoratet, 2016). The Cervid Regulations serve as a key resource for cervid managers.

Introduced or invasive big game species are regarded as non-native species that should not spread. Large carnivores are largely seen as pests that need to be kept at low population levels rather than to be valued as wild harvestable resources. However, lynx management has evolved toward sustainable harvesting of a renewable resource since it was formerly classified as a game species, unlike the other large carnivore species that are protected and culled for management reasons. Transitioning large carnivore management from pest control to sustainably hunted resources could be a goal. There is no national strategy or regulation-mandated municipal objectives for small game management. Holders of hunting rights must choose their own management strategies within the limits set by the Biodiversity Act and Wildlife Act and adherent regulations.

REGULATION OF ALLOWABLE TAKE

Allowable take depends upon population size and productivity, hunting effort (people × time) for a given area, and the effectiveness of the method used. Several regulations can govern hunting quotas:

1. **Hunting Season:** Determines when and for how long hunting can occur.
2. **Equipment Restrictions:** Limitations on weapon types, magazine capacity, use of communication devices and dogs.
3. **Hunting Effort:** Permitted hunter-days (number of people × number of days).
4. **Quotas by Sex and Age:** Distribution based on the age and gender of the animals.

Hunting season

Regulating the hunting season is a straightforward way to control the impact of hunting on the population. Both the start date and duration of the hunting season affect the number of animals harvested. Hunting seasons have evolved significantly over time, often set to protect wildlife but also to ensure a pleasant hunting experience. It has long been common to have protections during breeding seasons, both because no one wants to kill the parents of young animals and to allow young animals to grow to a harvestable size.

Non-native species like mink and wild boar can be hunted year-round. Populations are usually the smallest during breeding seasons, making culling most effective at that time. For example, the Norwegian Nature Inspectorate (SNO) keeps the wolverine population down by locating dens with snowmobiles and helicopters, then shooting the cubs before taking the mother.

Hunting seasons for males and females can be differentiated; females may be protected during breeding seasons while hunting occurs for polygynous males. In Scotland, roebuck hunting begins on April 1, in Denmark on May 16, in Norway on August 10, and in Sweden on August 16, while hunting roe deer with fawns starts once fawns are old enough. When author Brainerd worked for NJFF, he was able to advocate for an earlier season for roe deer bucks, from the 16th to the 10th of August, to provide hunters with more opportunities during the time when bucks can be attracted with calls. He did this in consultation with roe deer researcher Reidar Andersen, who opined that it should not have an adverse effect on roe deer populations. In Norway, capercaillie and black grouse males were once hunted on spring leks until 1932 (Skavhaug, 2005). Hunting a few males during displays likely had little impact on the overall forest grouse populations. Barth

(1891) was strongly opposed to display hunting, as it was too easy to kill too many birds. Today, it is even easier due to improved hiking and hunting equipment. Other arguments against display hunting include the ease of targeting older, tradition-bearing birds, which stay longest at the display sites, and that there is more sport in hunting forest birds in the fall, and that wildlife should be left undisturbed during the spring breeding seasons.

A 2020 ruling from the Inner Finnmark County District Court addressed spring duck hunting in Kautokeino (Indre Finnmark Tingrett, 2020). In Kautokeino, a short hunting period allows 150 hunters to each shoot one male duck from three common species. The court majority decided the defendant should be acquitted because unrestricted spring hunting of all ducks is an old Sami tradition. Sami people have traditionally valued hunting and eating fat ducks migrating from the south in spring, as they had lean meat supplies by then. They did not hunt ducks in the fall, preferring to target breeding animals instead of the production.

Beaver hunting in Southern Norway might be a parallel. Few beavers are hunted during the fall season, but hunting extends up until the earliest birthing times in spring. Pregnant females are then harvested, significantly impacting production. The biological argument for duck hunting in Kautokeino and for beaver hunting in Southern Norway is similar. The key difference is whether one follows established regulations. The presiding judge dissented in the district court case, which was appealed to the appellate court, where the defendant was convicted. This case is an interesting example of the tension between local and national traditions and attitudes.

If ducks and beavers are hunted in the autumn, the populations will be at their largest, allowing hunters to harvest more without harming the populations. If the Sami choose not to hunt ducks and Norwegians opt not to hunt beavers in the autumn but prefer spring hunting, it can still be sustainable, but they would need to harvest fewer animals. In various territories, pregnant female beavers might be harvested, leading to lower production. Mallards often pair up in the fall, but the male leaves the female after mating. It is likely that female mallards will still find mates even if the male is harvested, as mallards are known for being promiscuous.

A fixed hunting season without quotas is a simple yet imprecise management method, particularly when there is little knowledge about population size. In Norway, the hunting season begins on September 10 for upland game birds, which is suitable for unmonitored populations without restrictions on harvest. Typically, birds stay hidden for at least a week after the hunting season begins, before flocking together and taking flight before hunters reach them. The hunting season reduces the chances of overharvesting. With quotas based on population surveys, it would be feasible to start the hunting season earlier, as in Sweden, where the hunting season begins on August 25.

Equipment restrictions

Even in Magnus Lagabøte's national law from 1284, using skis for moose hunting was prohibited as it was probably deemed too effective. The Norwegian Hunting Law of 1899 was amended to include a ban on firearms with multiple cartridge magazines for wild reindeer hunting in 1908. Currently, EU regulations prohibit automatic weapons and semi-automatic rifles and shotguns with more than two shots in the magazine. In Norway, shotguns cannot have more than two shots before reloading is required. All these rules decrease hunting efficiency but also probably reduce wounding loss as hunters cannot rely on many shots when shooting at game. It is also illegal to use motorized vehicles during hunting. Hunting from a motorboat in coastal areas is allowed if it is more than 2 km from land. It is forbidden to use aerial drones to locate game.

In the USA, equipment restrictions are commonplace, and each state annually issues comprehensive regulation books for hunting small and big game. In Idaho in 2020, it was illegal to use electronically produced calls to attract game, and dogs could only be used for hunting black bears and cougars. In many states, like Alaska, using dogs for tracking wounded game or electronic communication devices like hunting radios to enhance hunting efficiency is prohibited, though these rules are challenging to enforce in the age of smartphones. Hunters cannot hunt big game the same day they have been airborne in a small aircraft to prevent harvesting animals located in the air. New regulations also limit the use of game cameras for hunting, prohibiting hunting the same day an animal is photographed. These rules aim to ensure fair hunting practices. Nonetheless, baiting bears with human food to increase hunting efficiency has become more common (Repanshek, 2023).

Big game, small game and lynx can be hunted with dogs in Norway. It is generally prohibited to use barking dogs to track wolves, though the County Governor can grant exemptions for depredation control hunting. Landowners can also prohibit hunting with dogs on their property. Hunting with bird dogs may be restricted early in the season when birds are more likely to stay hidden in order to reduce harvest. However, such bans are often rooted in traditional fears that dogs might harm sheep that are still grazing on the summer range in early September.

Restricting hunter effort

Hunting effort can be limited by controlling how many hunters are allowed in a given hunting area. In specific areas, managers often restrict the number of hunting permits or the number of hunters simultaneously. When the state-owned forest company Statskog opens new areas for hunting in management zones, they start by allocating 2 to 5 km^2 per day per grouse or hunter. Then they measure the harvest and adjust allocations accordingly (Jo Inge Breisjøberget, Statskog, pers. comm.). Willebrand et al. (2011) showed that grouse harvest was particularly determined by the number of days hunters were active in a management unit. If hunting pressure is up to three hunter-days per km^2, it is unlikely that more than 30% of the population will be harvested. In Sweden, state-owned land is divided into suitable management zones, allowing three hunter-days per km^2. Hunters register online when and where they plan to hunt, and once the hunting effort reaches the limit, the zone is closed. They believe this method keeps harvesting at a reasonable level without knowing the grouse density in the specific area. In Norway, restricting the number of hunter-days is less effective because grouse hunting starts so late that grouse are less likely to stay hidden and hold for a dog and quickly become harder to harvest.

Quotas and bag limits

In the USA, wildlife is publicly owned. Hunters generally have good access to public land, although private landowners may restrict access. Therefore, it is common for state authorities to set quotas for small and big game to 1) prevent overharvesting and 2) distribute wildlife resources among the state's residents. For small game, there might be two simultaneous quotas: a daily bag limit as well as a possession limit. For example, the bag limit might be two birds, with 10 birds allowed to be in possession during a hunt to be taken home. If the hunter wants to harvest more, they must consume or give away the birds, so they never possess more than 10 at any given time. In the USA, the meat, antlers/horns or hides of harvested game cannot be sold; however, the skins from animals classified as furbearers may be sold.

Small game quotas in America are set based on various criteria. For mallards, models estimate the number of ducks migrating through the central USA and Canada, based on a combination of population estimates and the number of rain-related ponds in breeding areas (Figure 8.3; Nichols et al., 2015). This estimate and experiences from previous years are used to set quotas. It is interesting to search for "hunting regulations" and an American state online to see the various, highly detailed rules. Duck quotas can be quite specific. In Idaho in 2020, hunters could harvest seven ducks per day, but no more than two female mallards or one or two of four other species. Autumn populations of fast-reproducing species depend entirely on reproduction. Quotas for many species are set before they have reproduced. In Idaho, decisions on whether to allow sage grouse hunting are made after spring mating season surveys, with two or seven days of hunting permitted and a quota of one bird per day, depending on the number of males at the display sites. When author Storaas hunted birds in Finland, each hunter received seven personal points, which could be used for one female capercaillie or seven ptarmigans. Storaas shot one ptarmigan and was then prevented from shooting a female capercaillie that he flushed later.

Guthery et al. (2004a) and Guthery et al. (2004b) found that fixed high quotas had no impact in years with low densities because hunters could not meet the quota. In productive years, when quotas were unnecessary, they could limit the harvest. For quotas to be effective, they had to be low. Guthrey and colleagues mention that low quotas are not problematic; in dense populations, harvest is limited, but hunters can hunt more days and thus harvest more birds.

In Norway, the Environment Agency previously set hunting seasons without quotas for small game, but in 2022, female eiders were protected, and a quota was set for males. Several studies (e.g., Rolland et al., 2010; Sandercock et al., 2011; Frye et al., 2023) show that hunting can reduce the breeding population of the following spring under certain conditions. Large landowners such as Statskog, Finnmark Property, many mountain boards and private owners have started setting quotas for small game as well. Breisjøberget et al. (2017) found that a daily quota of four ptarmigan per hunter per day had little impact on the harvest on state land in Nordland during average years with poor reproduction. To reduce the harvest by half, the daily quota would need to be one ptarmigan per hunter. Therefore, ptarmigan managers set quotas after surveying populations in August.

For big game, specific sex and age quotas are common. For ungulate game, it is common to have restrictions based on antler or horn size. In Norway, big game quotas are usually given to specific hunting teams in an area. In the USA, hunters must purchase individual permits and cannot transfer their tag to someone else in their hunting party in most cases. This is practically difficult to control. In New Hampshire in 2020, it was illegal to hunt cervids in groups larger than five, and they cannot use dogs, making large drives difficult to execute. However, hunting regulations and allowable methods vary between states to some extent.

Refuge areas

When growth rates in wildlife populations across landscapes are thoroughly studied, it often turns out that the species thrive and reproduce well in certain areas, known as source areas, and less so in others, known as sink areas (Sæther et al., 1999). This is generally considered to be due to varying habitat quality (e.g., Pulliam, 1988). However, populations in refugia from hunting, or that are lightly hunted, may export individuals to areas that experience heavy hunting pressure. For example, Frye et al. (2022) found heavy hunting pressure on willow grouse near roads in autumn, but there was little pressure far from roads. In winter, populations mixed, and grouse from afar somewhat compensated for the heavy hunting pressure along a main highway in his study area. Smith and Willebrand (1999) also showed that willow grouse migrating from protected areas somewhat compensated for hunting losses in Sweden. It may yield the best results to protect the source area, calling it a refuge area, and allow unrestricted harvesting in the sink area (Lundberg & Jonzen, 1999). The realism of such models is uncertain (Jonzen et al., 2001). A form of refuge area model has been tried in Norway for predator management: wolves can be culled outside the wolf zone, but a few packs within the zone are left undisturbed. Creating refuge area models for harvestable wildlife requires large areas under unified management. Few landowners with good ptarmigan territories are likely to want to protect them, so neighbors can harvest freely. Statskog tested a refuge area model in a mountainous region in Nordland. Hunting pressure even in the sink area was low, making it difficult to measure any effect. Additionally, hunters were not particularly enthusiastic about the arrangement (Breisjøberget et al., 2017).

AUTHORS' REFLECTIONS

Direct exploitation of organisms is considered the second strongest driver of changes in nature. As we define hunting, it poses no threat to species or biodiversity. Hunters rely on well-functioning ecosystems to pursue hunting and have been advocates for area protection. Internationally, hunters have preserved much wildlife habitat. In Norway, the Norwegian Association of Hunters and Anglers (NJFF) works to protect wild reindeer mountains and prevent developments like wind turbine parks in wilderness areas. Hunters provide population information on many species. For example, wildlife researcher Emmanuel Menoni works hard to maintain a small harvest quota on capercaillie in the French Pyrenees so he can have an enthusiastic team monitoring display sites and providing information on population production and development.

Hunters seek robust populations that can withstand hunting. Predators often keep prey populations well below both ecological carrying capacity and production potential. Hunters desire less predation, not necessarily fewer predators. Populations of small predators are generally limited by food availability and can tolerate intense hunting and trapping. We need more knowledge on how to reduce carrying capacity of predators. Wolverines, lynx and bears may be becoming more attractive to hunters as game and less so as competitors. However, wolves kill hunting dogs and thus hinder hunting with dogs for big and small game in many wolf territories. The NJFF national assembly has advocated for lower population targets for wolves than those set by the Norwegian Parliament. It is challenging for NJFF's members to both preserve all nature and simultaneously be able to hunt with dogs where they live.

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12. Cervid management

Cervid populations are a significant resource but can also damage forests and fields and be involved in traffic accidents. These cover large areas, and effective management requires good collaboration, especially between landowners and government authorities. We will discuss multi-species management, the national cervid management strategy and the special situation regarding wild reindeer management. Moose, red deer and roe deer are managed by the municipalities through national policy and legislation now administered by the Agriculture Directorate. Management of moose and red deer are somewhat similar, while roe deer management differs due to their faster, more r-selected nature and less predictable population development compared to other cervid species. In contrast, wild reindeer are dually managed by the Environment Agency and the Agriculture Directorate. We will cover wildlife traffic accidents and reflect on challenges in cervid management. A new cervid strategy and regulations are being developed, but their specifics are not yet known as of this writing.

MULTI-SPECIES MANAGEMENT

Cervid management was simpler a few decades ago with only one regionally dominant deer species (moose in the east, red deer in the west, reindeer in the mountains) and a lack of large carnivores. Today, moose, red deer and roe deer often compete for food, and large carnivores can take calves and adults. Moose managers must consider how forestry, as well as foraging by roe deer and red deer, affects food availability for moose. Managers must also account for local cattle herds that trample and can consume much more vegetation than do moose. Moose slaughter weights are not solely determined by available nutrition; female moose that matured during lean times produce small calves. It can take generations for slaughter weights to recover even after forage quantity and quality improve. It is also uncertain whether large moose will have an advantage anymore; perhaps global warming is leading to selection for smaller moose. Managers must consider historical population sizes, how forestry provides forage, total browsing impact (Wam & Hjeljord, 2023) and predator losses.

CERVID MANAGEMENT STRATEGY AND GENERAL REGULATIONS

In line with the Biodiversity and Wildlife Acts, a "Strategy for Cervid Management" was developed (Direktoratet for naturforvaltning, 2009c). The vision for the strategy is: "Valued locally, recognized globally."

The strategy has five specific goals. Cervid management shall:

1. Ensure viable and healthy deer populations, rich biological diversity and nature's future production of goods and services.
2. Have broad societal acceptance and legitimacy.
3. Ensure cooperation and interaction between local, regional and national actors and with affected sectors.
4. Be based on high competence at all levels.
5. Stimulate increased quality and diversity of experiences, services and products.

The strategy sets specific sub-goals:

1) To increase political and societal awareness about the importance of cervid species as a natural resource and the significant challenges faced by management, and to establish clear and agreed-upon overarching goals and effective cross-sectoral collaboration to address these challenges.
2) To demonstrate that hunting is a part of our cultural identity and use the uniqueness of the Nordic harvesting culture to generate increased interest and acceptance among broad segments of the population. At the same time, it involves facilitating access to big game hunting so that a larger proportion of hunter course candidates begin with cervid hunting.
3) To reduce the number of traffic collisions to achieve both better natural resource management and safer, more efficient transportation.
4) To establish a national competence center for guidance, data access, and expertise that helps regional and local management achieve established environmental goals.
5) To ensure deer management of high international quality by enabling Norwegian research environments to produce research-based new knowledge and new management tools, as well as opportunities to make this available at local and regional levels.
6) To develop a cervid portal as a comprehensive website for and about deer species for all users with internet access. The portal shall function as the official communication gateway related to cervids and cervid management for defined target groups as well as the media and the general population.

7) Establish a solid and predictable financial foundation for all measures and activities necessary to implement the strategy.
8) Adapt to a changed demand and consumption pattern among tomorrow's hunters and recreational users by developing a greater diversity of products and services, as well as encouraging and facilitating investments that can increase value creation associated with deer as a resource.
9) View timber production and (deer) wildlife in a holistic perspective to find good models for the best possible economic and ecological utilization of forest products.

Pedersen et al. (2021c) evaluated the strategy, noting that responsibility for achieving goals was not clearly defined, and no funds accompanied the strategy. While the strategy itself was good, only the initiative for the Cervid Portal was considered a success. Any new strategy should be supported with defined responsibilities and funds.

The cervid strategy has been continued in the Cervid Regulations (Miljødirektoratet, 2016), which define technical terms and show how deer should be managed. Reindeer councils with members from municipalities within reindeer areas manage wild reindeer on behalf of the Environment Agency and Agriculture Directorate. Municipalities are responsible for managing moose, red deer and roe deer. Each municipality, in consultation with landowners and hunters, should set goals for the development of moose, red deer and roe deer populations. Landowners must organize into hunting units that receive harvest permits. There is a strong desire for these units to organize into population management areas and develop population plans that must be approved by the reindeer management council for reindeer and the municipality for moose, red deer and roe deer before permits are issued. Harvest permits are distributed to those with hunting rights based on the proportion of the total area they manage.

Each harvested animal incurs a harvest fee. Wild reindeer management councils receive fees for this species which can be allocated to the appropriate reindeer management area as needed. Fees for other species go to municipal wildlife funds. Unfortunately, 80% or more of municipal wildlife fund resources were spent on collecting roadkill in half of the surveyed municipalities (Pedersen et al., 2021c).

WILD REINDEER

The genus *Rangifer* first appeared during the early Pleistocene with fossils found in both Eurasia and North America, and today there are many subspecies on both continents (Harding, 2022; Andersen & Strand, 2024). Norway is home to the Norwegian wild reindeer (*Rangifer tarandus tarandus*). It is managed as 1) semi-domesticated reindeer, as 2) free-ranging livestock managed through hunting and as 3) wild reindeer. There are now about 240,000 reindeer in Norway, and over 600,000 in Fennoscandia and Iceland. Today, the domesticated reindeer industry is characterized by the use of natural grazing and a herding regime with relatively distant contact with the animals, with gatherings a few times a year (Røed et al., 2021). Free-ranging livestock occur in Rendalen and Vossa/Kvammafjella (Reindeer Husbandry Act 1978, § 16; Paus, 2001). In Norway, wild reindeer are not owned by anyone. However, free-ranging livestock reindeer that are owned but not herded are managed through hunting. Semi-domesticated reindeer and free-ranging reindeer as livestock are managed according to the Reindeer Husbandry Act, while wild reindeer are managed according to the Wildlife Act and the Cervid Regulations. Sverre Fjellheim (1999) emphasizes that the wild reindeer population had to be reduced before, or preferably in parallel with, an expanded domesticated reindeer industry (NOU, 2007:14, p. 45). Of over 600,000 reindeer in the Nordic countries, only under 5% occur as wild reindeer in the Southern Norwegian mountains where the domesticated reindeer industry has not established.

Wild reindeer occur in nomadic herds in mountainous areas that often encompass several municipalities. There are 23 more or less isolated wild reindeer management areas (WRMA) where most wild reindeer occur. Norway has a special responsibility for wild European mountain reindeer since the last herds occur here. The 10 most important areas are defined as national WRMA divided into two administrative regions with nine wild reindeer councils (WRC; Figure 12.1[1]). In addition, there are two national wild reindeer centers for guidance and information, with one located at Skinnarbu in the southern administrative areas and the other in Hjerkinn in the northern administrative area.

After each municipal election, the municipal council appoints two representatives, a man and a woman, for each wild reindeer area within the municipality's territory. The Norwegian Environment Agency designates one of these representatives to the wild reindeer committee, which manages the reindeer in the area on behalf of the agency, not the municipality they represent. Many landowners have rights within the wild reindeer areas. They are encouraged to organize into wild reindeer landowner groups (WRG) that aim to protect their interests and to develop multi-year management plans for approval by the wild reindeer committee. These WRGs can organize monitoring, and assessments, and serve as the voice of the landowners in dealings with the committee, authorities and the public.

1 Modified from https://www.miljodirektoratet.no/ansvarsomrader/arter-naturtyper/vilt/villrein/

Anyone interested in wild reindeer can choose to become a member of the Wild Reindeer Council (WRC)[2], where public and private stakeholders meet to discuss common issues. The national WRC also annually publishes the journal *Villreinen*[3], where a wealth of information about wild reindeer and their management can be found. When author Storaas served on the WRC for Rondane and Sølnkletten (2016–2019), he was astonished by the significant pressure for development and use of the Rondane WRMA. The main role of the WRC is to serve as a consultative body on matters regarding interventions, measures and activities within the WRMA. It was humorously noted in the committee that knowing just one word, "NO," was essential for maintaining wild reindeer populations.

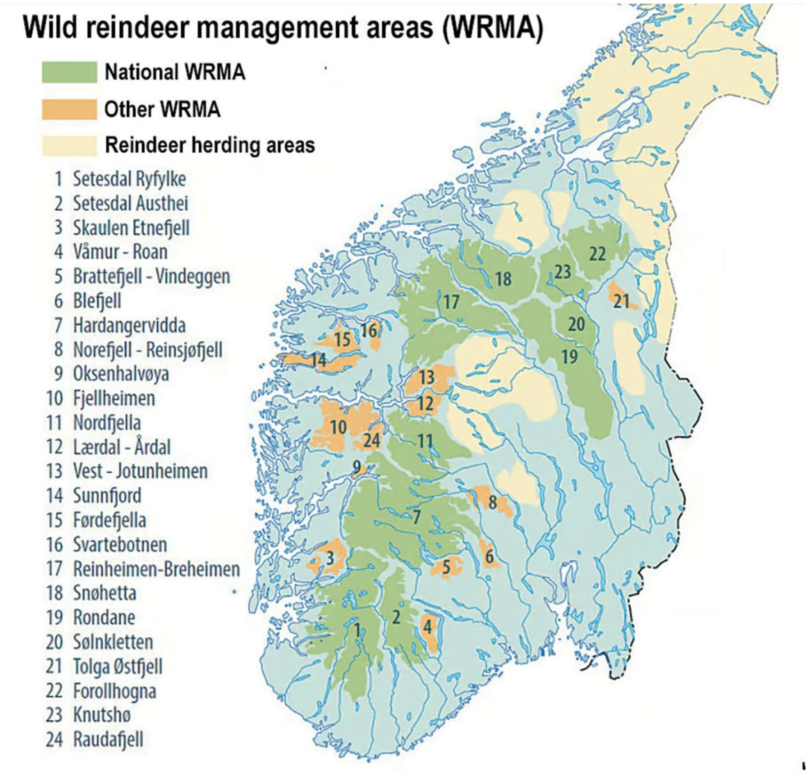

Figure 12.1: Overview of the 23 Norwegian wild reindeer management areas (WRMA). The 10 WRMAs of national importance are designated in green. The figure is derived from the Norwegian Environment Agency, Norwegian Wild Reindeer Center and Anders Mossing.

2 https://villrein.no/villreinradet/

3 https://villreinen.no/

The Norwegian Environment Agency has developed a Quality Norm for Wild Reindeer (Kjørstad et al., 2017; Ministry of Climate and Environment, 2020). This norm assesses population conditions, lichen grazing, habitat and human impact by considering factors such as sex-adjusted slaughter weights for calves, the number of calves per 100 females and juveniles, the proportion of older (≥3 years) males per adult (≥1 year) females, genetic variation, health status, lichen biomass, functional land use and migration corridors. Thus, the WRG involved in planning and approving WRC have quality standards to guide their management efforts.

The quality norm provides an assessment of measurement parameters and sub-norms giving each wild reindeer area by employing a traffic light system based on the sub-norm with the lowest quality: green (good condition), yellow (medium condition), or red (poor condition). The sub-norms are 1) population condition, 2) lichen forage condition and 3) overall range health and human impacts. Yellow and green are considered acceptable, while red indicates significant challenges and an unacceptable state. This classification highlights the main issues in each area, aiming for all areas to reach at least medium quality. In the long term, the goal is for national WRMA to achieve good quality.

Due to resource considerations, classification is done in two phases. The 10 WRMA were assessed first in early 2022, and the 14 smaller areas were evaluated in fall 2023. None of the national WRMA were rated green. Four WRMA—Forollhogna, Sølnkletten, Reinheimen-Breheimen and Setesdal Austhei—received yellow ratings for medium quality, while six WRMA—Knutshø, Snøhetta, Rondane, Nordfjella, Hardangervidda and Setesdal Ryfylke—were rated red for poor quality. Among the non-national WRMA, Brattefjell-Vindeggen, Fjellheimen, Førdefjella, Skaulen-Etnefjell, Sunnfjord and Svarteboten were rated poor, while Blefjell, Lærdal-Årdal, Norefjell-Reinsjøfjell, Oksenhalvøya, Raudafjell, Vest-Jotunheimen and Våmur-Roan received yellow for medium quality. Only Tolga Østfjell was rated green, indicating good quality[4]. Tolga Østfell is a WRMA in the special category of free-ranging livestock reindeer; in Rendalen municipality they are considered to be privately owned livestock, and in Tolga municipality they are considered to be wild reindeer. This disputed status is due to the fact that semi-domesticated reindeer were released as livestock in Rendalen 100 years ago but people in Tolga municipality believe they mixed with the last remaining free-ranging wild reindeer in their municipality.

The population management plan for each WRMA sets a target for the size of the winter herd, which is often a compromise. The herd should be small enough to have ample access to food but large enough to utilize the entire alpine range

4 https://villrein.no/kvalitetsnorm/

they inhabit. After assessments, managers, and preferably the WRC, can set quotas to achieve the population goal. The hunting quota must be adjusted to ensure the proper post-hunt sex and age structure. According to the quality norm, there should be at least one mature buck (>3 years old) per three females (≥1 year old) after the fall hunt. Punsvik and Jaren (2006) emphasize the need for enough mature bucks, noting that using the category "female/young buck" often results in too many young bucks being hunted, hindering the recruitment of mature bucks. They suggest using more female-only permits but do not elaborate on age and sex distribution. Approved population plans in different WRMA indicate that the distribution of harvest by age and sex generally aligns with assessed populations and plan goals, yet combined female/young buck permits remain common. Despite agreement on the importance of mature bucks, authorities justifiably deviate from management goals by targeting mature bucks and keeping the population young in Hardangervidda to eliminate CWD, as mature bucks are more likely carriers of the disease.

Hunting wild reindeer poses challenges since they live in herds and move against the wind. Often during hunting season, reindeer are only in small parts of the area, and only those with hunting rights there can hunt them. To ensure that enough animals are hunted, the wild reindeer committee often issues more permits than the population size, which seems imprecise when only 10% of the permits are used. Author Brainerd had to explain the rationale for this to the BBC World News in the mid-1990s, when they noted a sensational newspaper headline stating that the Hardanger Plateau wild reindeer quota was larger than the actual population! Biologically, it works since the distribution of permits by sex and age matches the overall area's population, but landowners may face restrictions even if they have not hunted where the animals are for years. Transition arrangements exist in many mountainous areas, allowing hunters from areas without reindeer during the season to hunt in neighboring areas.

The evaluation of the Cervid Management Strategy (Pedersen et al., 2021c) reveals that most stakeholders view wild reindeer population management as adequate but see land management as the biggest challenge. Regional plans aim to protect WRMA but are not binding. Wild reindeer are culturally significant in many communities, but municipalities and businesses typically earn more from cabin construction and tourism than from wild reindeer, something which increases pressure on reindeer range. Enthusiasts also desire restoration of reindeer range and migration routes, requiring measures like removing cabins, dynamic travel bans, and rechanneling road and rail segments in underground tunnels. Protecting and restoring wild reindeer range will cost large amounts of money similar to preserving other national treasures like Viking ships and historical artifacts.

A parliamentary report on wild reindeer (Meld. St. 18 (2023–2024)) advocates for their protection but leaves many decisions to municipalities. Hunter and conservation organizations consider the action plan weak (e.g., Haug, 2024). Numerous suggestions have been made to limit human activities, and individual action plans for various wild reindeer areas are being developed.

MOOSE AND RED DEER

Municipalities are required by the cervid management regulations to set measurable goals for the development of red deer and moose populations. These populations can be managed in terms of 1) numbers and 2) sex and age composition. The number of individuals and their composition determine forage needs and production. A municipality might set two goals: one for population size and one for winter herd structure. It is common to adjust the population to the available winter forage. Red deer typically browse on species like rowan (*Sorbus aucuparia*), aspen (*Populus tremula*) and willow (*Salix* sp.), but can damage young pines, remove young spruce terminal buds and gnaw bark. The perceived appropriate foraging pressure varies. Measurement methods can affect results; forests considered undamaged by Norwegian methods might be seen as completely damaged by Swedish methods (Zimmermann et al., 2022) since the Norwegian method measures browsing pressure whereas the Swedish method measures forest damage.

The Forestry Act § 6 specifies how many undamaged spruce and pine plants should grow per unit area by site quality and species after logging, and § 9 mandates municipalities to assess whether the population should be regulated to reduce grazing pressure. The cervid management regulations also state that the impact on biological diversity should be considered. Conflicts can arise between landowners wanting to hunt red deer and farmers whose grass is eaten by them. Issues also occur when animals are hunted on the fall range and migrate to the winter range owned by others. In some municipalities, wildlife collision numbers might influence desired population size. The municipality should facilitate a process where all stakeholders can agree on goals, which should be accompanied by indicators of the population's status relative to management goals. Measured foraging impact in the spring can be one such indicator (see Chapter 7, p. 177). Several methods have been developed to measure the grazing impact of red deer and moose (Solbraa, 2008; Grindstad, 2014; Skogkurs, 2017; Skogstyrelsen, 2021). Instead of using foraging pressure as an indicator, municipalities might use calf and juvenile weights and reproduction rates. However, animal-related indicators show effects only after foraging pressure has decreased.

Once goals with indicators for population size are set, municipalities can decide on harvest goals. Johan Trygve Solheim from the Norwegian Red Deer Center[5] at Svanøy and experienced moose manager Kurt Gjerstad emphasize the importance of the post-hunt population structure in meetings and conferences. Gjerstad et al. (2003) categorized seven harvest models based on hunting duration and resource utilization. They found that the old method of harvesting large animals and shooting females from calves results in poor resource use and unethical practice, as calves typically die in winter without their mothers. Sæther (2012) called for more areas with experimental harvesting to evaluate the long-term results of different strategies.

Landowners benefit from organizing into population plan areas. These areas receive flexible permits to be used according to the population plan, allowing permits for more animal categories than municipalities can offer. Those holding hunting rights can agree to hunt more or fewer animals in different parts of the area. Quotas are allocated based on the minimum area required for one permit. The desires of population plan areas weigh heavily when municipalities set goals for red deer or moose population development. Municipal goals vary widely; some are general and difficult to evaluate, others are detailed, and some seem more like measures than goals (Pedersen et al., 2021c). Hegland and Frøyen (2015) thoroughly reviewed the municipality's role in moose and red deer management, how collaboration can set goals and how goal implementation can be funded.

Solberg et al. (2021) have produced a comprehensive report on harvest strategies for moose and red deer. While the cervid regulations are considered the bible for wildlife managers, it might be more accurate to say they are the Old Testament, and the Solberg report is the New Testament. The report reviews existing literature, creates models, and calculates how populations develop with different sex structures and hunting quotas. Sex distribution is crucial, as a single large male can mate with many females. In livestock farming, cattle breeders reverse the sex ratio to almost exclusively females, inseminated by a few select males. In the wild, this approach has drawbacks. Sæther (2012) points out issues with skewing the sex ratio to have many females per male, including a low average age for males, young males using resources for breeding that should be used for growth, females with delayed estrus leading to late-born calves and males not reaching full maturity.

Solberg et al. (2021) vary the female-to-male ratio between 1:1 and 2:1 in their models and adjust harvesting from primarily calves and juveniles to mainly adult

5 https://www.hjortesenteret.no/

animals. They assume population size is determined by available winter forage. They demonstrate that no strategy meets all management goals and summarize four yield-oriented strategies, one community-oriented and one conservation ecological hunting management strategy (Table 12.1).

Table 12.1: Summary of the main elements in various hunting management strategies (Solberg et al., 2021).

Hunting Management Strategy	Management Goal	Harvest Strategy	Sex Ratio	Advantages	Disadvantages
Yield-oriented – number of animals hunted	Maximum harvest of animals	High proportion of calves and juveniles (> 70%)	Maximally female-dominated (2:1)	Many shooting opportunities, low hunting effort, low winter population, low summer grazing pressure	Few older males, genetically vulnerable, moderate meat yield, emotionally challenging
Yield-oriented – meat yield	Maximum meat harvest	Low proportion of calves (<10%)	Maximally female-dominated (2:1)	High meat yield, less emotionally challenging	Moderate animal harvest, few older males, genetically vulnerable, high winter population and hunting effort
Yield-oriented – number of trophy animals	Maximum harvest of mature males	Low to moderate proportion of calves (10–30%)	Balanced (1:1)	High harvest of older males, lower winter population and hunting effort	Low meat and animal harvest
Yield-oriented – maximize hunting yield	Optimize the harvest of animals, meat and trophy animals	Low to moderate proportion of calves (10–30%)	Female-dominated	High economic return for hunting rights holders	Few older males, genetically vulnerable population
Community-oriented – maximize utility	High and efficient harvest of animals, meat and trophy animals	Moderate to high proportion of calves (20–50%)	Female-dominated	High harvest of animals and meat, low hunting effort, low winter population	Few older males, genetically vulnerable population
Conservation ecological – original population structure and condition	Maintain original population structure and mortality pattern	High proportion of calves (>50%) and yearlings (10–20%)	Balanced (1:1)	High proportion of older animals in the population, genetically robust, high weights and fertility rates	Low meat and older male harvest, few shooting opportunities, emotionally challenging

Table 12.1 serves as a much-needed tool for setting municipal goals. Municipalities can either choose to 1) harvest the maximum number of animals; 2) maximize meat yield; 3) harvest the most trophy animals; 4) optimize the harvest of animals, meat and trophies; 5) achieve high and efficient harvests of animals, meat and trophies; or 6) maintain an original population structure and survival pattern. Once the goal is selected, the harvest strategy and sex ratio are defined. Langen (2024) mentions that the Norwegian Environment Agency is working on a new cervid management strategy focusing on animal welfare, with the main goal of managing species to ensure robust populations. This suggests a preference for more conservation-oriented harvest models.

Let us look at some models chosen by major knowledgeable organizations such as The Swedish Association for Hunting and Wildlife Management, the state-owned Land and Forest Company Statskog SF, and the former Borregaardskogen company The Swedish Association for Hunting and Wildlife Management's guidelines (2015) align closely with a community-oriented utility model. They have several hunting rules to ensure a sufficient calf harvest and enough mature males during rutting. The guidelines state that in the adult population, there should be 1.5 females per male and more than 0.8 calves per female. They aim to shoot at least as many calves as adults (1.5 years and older), with mature males hunted post-rut unless strict male quotas are in place. Throughout the hunt, more calves than adults should be harvested; if one adult is shot, a calf must be shot before the next adult. Their action plan for moose (Svenska Jägareförbundet, 2020) emphasizes maintaining a fairly small but highly productive moose population.

Statskog's guidelines for moose management (Statskog, n.d.) also lean toward community-oriented utility. They aim to maintain the population level to harvest 80% of the allotted quota. They strive for no more than harvesting 1.5 females per male over time, ensuring 50% of the harvest consists of calves. To avoid shooting males too young, no more spiked males than yearling females should be harvested. Another option they mention is counting juveniles as adults. By shooting 50% calves, the remaining harvest consists of 50% adults, aiming for a roughly 50/50 sex ratio.

Experienced moose manager Frank Robert Lund from the former Borregaardskogen company in Gravberget aimed for a more conservation-oriented model, as described in his lectures. He preferred an equal sex ratio of females to males and a harvest composition of 20% males, 20% females and 60% calves, focusing on hunting many small and young animals. The pricing system favored harvesting lighter animals, allowing robust young ones to remain. Males needed time to mature, hence males aged 1.5 and 2.5 years were protected, while weak animals were culled. Lone females, including yearlings, were hunted only in the first week, with all calves except one of twin pairs protected during this period.

Afterward, only calves and remaining males were harvested, ensuring many calves were harvested while maintaining a substantial number of mature males in the population.

There has been discussion on the impact of various antler restrictions on the genetic development of moose populations. Mysterud (2014) concludes that these restrictions likely do not make a significant difference. He suggests that the best approach might be to allow more bulls to grow to maturity, as few develop large antlers before reaching full maturity.

The models mentioned above ensure the presence of mature males in the population. Our strong impression is that most experienced managers prefer slightly lower populations with good access to high-quality nutrition. They aim for nearly equal numbers of males and females, a high average age among adults, and to harvest primarily young animals. Adult males should ideally reach their peak in body and antler development before being harvested. However, it is the municipalities, in collaboration with landowners and hunters, that set the goals, not the administrative managers.

Managing areas with several large predators can be more challenging. Bears take few adult moose (Dahle et al., 2013) but do prey on some young calves in areas with many bears. Cows can then use all available nutrition to rebuild themselves, often resulting in twin calves the following year, with calf losses equating to 22% of production (Swenson et al., 2007). Thus, the impact of sparse bear populations is limited. Wolves have a greater impact. Jonzen et al. (2013) calculated that levels of moose harvest could be maintained in new wolf territories if the population was increased and the sex balance skewed toward cows. This is considered theoretical, as increasing populations generally lead to more browse damage, and having more than two cows per bull is detrimental to the moose population. Wikenros et al. (2021) found that moose harvest per unit area decreased by 51% in Sweden and 37% in Norway in wolf territories compared to areas without wolves. In both countries, fewer cows were hunted in wolf territories. In Sweden, fewer calves were harvested, likely because wolves prey on calves. In Norway, more calves were hunted, likely because cows were spared. Managers adjusted hunting to account for wolves, and hunters had a greater influence on population development than wolves did (Wikenros et al., 2015).

It is common to lease hunting rights in a specific area to one hunting group. They often do not always harvest all their allotted animals, sometimes due to time constraints, particularly if quotas are large or hunting conditions are difficult. Statskog has introduced a new innovation, by selling day permits for remaining quotas, allowing more hunters and thereby increasing moose harvests (Breisjøberget, 2018).

ROE DEER

According to the cervid management regulations, roe deer are classified as big game, and municipalities must set goals and establish minimum areas for them as well. Municipalities can require harvest plans. Roe deer are more r-selected compared to other cervid species. Factors such as snow depth, cold, food availability, lynx populations and, to a lesser extent, hunting affect roe deer survival during winter. Red foxes also kill a significant but varying portion of newborn roe deer fawns (Jarnemo & Liberg, 2005). Many roe deer fawns are killed during hay mowing. There are examples of volunteers using drones to locate and move fawns before mowing (Straube, 2021). Consequently, reproduction and survival rates vary greatly, making it difficult to establish harvest plans in spring for the following autumn and beyond. Given its biology, there is debate about whether they should be defined as big game managed by municipalities or small game managed by landowners. In Sweden, roe deer are managed as small game with unrestricted hunting until January. Norwegian municipalities often place little emphasis on managing roe deer (Pedersen et al., 2021c, p. 27). This challenge is addressed by allowing hunting without quotas for roe deer areas with 20 times the minimum area or at least 10,000 decares.

Earlier, minimum area quotas were required for roe deer in Norway; in 1995, author Brainerd argued for a quota-free system in his role as wildlife management consultant with the Norwegian Association of Hunters and Anglers (Brainerd, 1995). This has since been implemented, allowing greater freedom for local managers. While some management areas may include quotas for roe deer in their management plans, it is no longer a national requirement. It should be mentioned here that roe deer harvests decreased dramatically after the winter of 1994, which provided good snow conditions for the Lillehammer Olympics but hammered the roe deer population. This experience emphasized the fact that other factors influenced roe deer numbers to a greater extent than human-caused mortality, and that roe deer probably should be managed more as an r-selected species with great variation in reproduction and mortality.

Different countries have varying hunting seasons for bucks. In Sweden, Denmark and the United Kingdom, there is spring hunting for bucks. In the UK, buck hunting extends from April 1 to October. In Sweden and Denmark, hunting is closed during summer, reopening in Sweden on August 16, late in the rut, and in Denmark after the rut. Author Brainerd was involved when Norway's buck hunting season was moved to August 10, allowing bucks to be hunted during the rut. This provides good hunting opportunities but may lead to few mature bucks surviving, resulting in a younger buck population if harvest pressure is heavy over a larger area. If landowners desire mature bucks in the population, harvest should be carefully managed by those familiar with the buck population in the area. An informal study based on interviews of several roe deer enthusiasts, including managers and a researcher, was conducted regarding roe deer management (Bakka, 2025; Bakka & Berglund, 2025). Unrestricted hunting and springbuck hunting, as in Sweden and Denmark, lead to skewed sex ratios and a young buck population when landowners fail to create collective population plans over larger areas. Interviewees believe detailed plans for roe deer populations over larger areas, considering factors like snowy winters, would be best. With good goals and plans over larger areas, hunting and populations can be effectively managed.

The late roe deer expert Vidar Holthe suggested buck hunters record the sex and age of all deer seen during the August hunt. Over time, this data can provide managers with an immediate snapshot of the population just before regular hunting, allowing them to set quotas to prevent overharvesting (Fjare et al., 2015).

WILDLIFE COLLISIONS

People rely on transportation routes such as railways and roads, which range from unpaved rural roads to four-lane highways. Wildlife, like moose and wolves, are affected by roads depending on their traffic volume and size (Loosen et al., 2021b). Wolves, foxes and moose often use less traveled roads to move through landscapes, which can impact other species. However, the biggest traffic challenge for moose, red deer and roe deer is collisions and the increasing barrier effect as traffic increases. At about 20,000 vehicles per day, wildlife usually stop attempting to cross. New, larger roads are fenced to prevent wildlife accidents, but these fences also create complete barriers. When wildlife fences are installed, safe crossings, such as overpasses or underpasses, must also be created for wildlife.

Several overpasses and underpasses have been constructed for wildlife to cross the E6 highway and Gardermoen railway in Romerike. Roer et al. (2019) summarize reports from the Moose Project in Akershus (Kastdalen et al., 2018; Roer et al., 2018). Wildlife passages must be situated in the terrain so that animals can find them, and the longer the passage, the wider it should be. For underpasses, the height times width divided by length should be at least 2.5. Near Gardermoen, more moose used overpasses than underpasses, though this might simply reflect their locations. Wildlife passages should ideally be spaced a maximum of 1 km apart, but populations on both sides of the road can belong to the same genetic group even if the distance is longer. Moose stayed at least 100 meters away from roads and preferred using passages meant solely for wildlife. The more human use of passages increased, the less moose used them. Moose used random, non-designated openings the least. These reports provide useful information for future road project planning.

Wildlife collisions mainly occur on older roads without fences and crossings. Various measures have been attempted to reduce collision numbers. Reducing the moose population might lead to fewer collisions (Rolandsen et al., 2011), but snow depth, temperature and winter duration had an even greater impact in the mountain valley of Østerdalen (Storaas et al., 2005). Feeding, when legal, could counteract collisions (Andreassen et al., 2005; Eldegard et al., 2012), though more studies are needed to confirm this (Milner et al., 2014). Many factors contribute to moose collisions, making it difficult to conduct definitive experiments showing the effect of feeding. At Sætre Bruk in Hurum, owners fed roe deer to keep them near feeding sites and away from strawberry fields and roads (Lund, 2023). Feeding wildlife is common in many countries; in Austria, large parts of the wild cervid population are fed in enclosures during winter (Milner et al., 2014). Many are skeptical of feeding (see Mysterud, 2010). Since CWD was detected in Nordfjella in 2016, feeding wildlife without permission is now illegal in Norway (Mysterud et al., 2019b). Without feeding, more roe deer were hit by vehicles again in Hurum (Lund, 2023). Wildlife response to measures like scent repellents, light reflectors and other permanent installations seem to weaken through habituation, and Wildenschild (2022a, 2022b) suggests employing traffic warning signs and reduced speed limits when collision risks are high.

The 2009 Cervid Management Strategy aimed to reduce collisions. Rivrud et al. (2020) note that wildlife collisions have increased and are one of the greatest challenges in wildlife management today. Thirty years ago, the Action Plan for Cervid Management (Jaren et al., 1995), which author Brainerd helped formulate, had this as an important component, so it is clear this is a difficult issue to solve. Pedersen et al. (2021c) evaluated the strategy of the Norwegian Environment Agency, highlighting that stakeholders consider collisions a major challenge, but responsibility is fragmented. Many suggestions to prevent collisions have been proposed, but measures have rarely been experimentally tested or widely implemented. Pedersen et al. (2021c, p. 56) believe little will change until responsibility for collisions is clarified. They propose:

1. Clearly assign responsibility for wildlife accidents, possibly through establishing an overarching body dedicated to preventing them.
2. Municipalities should organize road collision groups (as currently done), but the costs for handling injured and deceased wildlife due to traffic collisions should no longer be covered by municipal wildlife funds.
3. Owners of transportation routes should pay additional fees per wildlife collision into a collision fund managed by the overarching body for accident prevention work.

The authors also state that "Wildlife collisions have increased as long as we've had statistics. To reduce them, transportation route owners must be held responsible and fined for wildlife collisions."

AUTHORS' REFLECTIONS

There is ongoing work on a new cervid management strategy and revised cervid management regulations and a recent parliamentary report on wild reindeer. The biggest challenge for wild reindeer is habitat loss due to our land management practices. Much former wild reindeer range (87%), particularly in Northern Norway, is occupied by the domesticated reindeer industry. Wild and domesticated reindeer are the same subspecies. Domesticated reindeer livestock become red-listed wild reindeer when they cross the boundary between Rendalen and Tolga municipalities. Reindeer as a subspecies itself is not threatened, but wild reindeer and its associated hunting culture are near threatened. The small areas available without domesticated reindeer are heavily pressured by other industries and outdoor activities. Hopefully, authorities will find precise measures that do not impose unnecessary restrictions on people's use of the mountains, but it is a difficult balance.

The current cervid regulations provide a solid foundation for management collaboration in year-round deer habitats. A challenge for effective management can be conflicting interests and a lack of cooperation among landowners with hunting rights. Property rights are strong, and the current legal framework cannot compel cooperation. There is also the question of how much public resources should be spent to improve cervid management for the benefit of landowners. It is uncertain what resources municipalities need to allocate for managing r-selected roe deer, where many factors beyond hunting significantly influence population development. Wildlife collisions will continue as before until transportation route owners incur sufficiently high costs from collisions to prompt preventive measures. It will be interesting to see the results of the work on the new wildlife law, deer strategy and deer game regulations.

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13. Grouse species

Grouse species include the rock ptarmigan, willow ptarmigan, hazel grouse, black grouse and capercaillie. Extensive books have been written about grouse management (e.g., Steen, 1978; Pedersen & Karlsen, 2007; Watson & Moss, 2008; Pedersen & Storaas, 2013b). First, we choose to write a bit about grouse species habitats, ending with an anecdote suggesting that grouse populations are largely not controlled by vegetation and logging classes. We will show how willow ptarmigan populations have changed over time and present and further develop the "God plays the one-armed bandit" hypothesis (Storaas & Punsvik, 1996). Two factors can be influenced by managers: 1) predation from predators and 2) human hunting. We discuss measures to limit predation before discussing ptarmigan hunting without and after surveys. We will present some knowledge points from the Ptarmigan Management Project (Pedersen & Storaas, 2013b). Finally, we discuss the January hunting of capercaillie and black grouse males and the protection of female birds, as many managers are concerned about this.

HABITAT FOR GROUSE SPECIES

The forest-dwelling grouse species are, broadly speaking, adapted to distinct successional stages in coniferous forests (Seiskari, 1962; Swenson & Angelstam, 1993). Willow ptarmigans live in clear-cut areas, often in higher elevation areas. After clear-cutting, grow, black grouse start to use regenerating stands. When regenerating spruce forest becomes properly dense, it becomes suitable for hazel grouse if alder trees are available. Capercaillie thrives best when the forest becomes old and starts to open up again and when trees die and fall down; here, hazel grouse thrive well in the old forest stands with openings that allow for alder growth (Swenson & Angelstam, 1993). However, we see large variations in the use of vegetation and logging classes throughout the year. Newly hatched capercaillie chicks forage on larvae in the forest understory, particularly on bilberry bushes (Wegge & Kastdalen, 2008; Wegge & Rolstad, 2023). During molting in the summer, adult birds fly poorly and prefer younger and denser forests, which the broods also use throughout the summer. When hunting begins in Sweden on August 25, both black grouse and capercaillie broods often sit in young forests that are too dense for goshawks and hunters. Some species can also migrate far between seasonal habitats (Mariakangas & Kiviniemi, 2005; Hörnell-Willebrand, et al., 2014b; Hörnell-Willebrand & Sjöberg, 2014; Arnekleiv et al., 2022).

The different species are distributed slightly differently also toward the mountains, with the rock ptarmigan highest up, the willow ptarmigan further down, and capercaillie, black grouse and hazel grouse in the forest (Kvasnes et al., 2010). Traditional wisdom dictates that there is a big difference in how many birds there are in different hunting areas. Kvasnes et al. (2017) found over time that in some willow ptarmigan management areas there were few and in others many, adult ptarmigans per unit area. The number of chicks each hen produced on average also varied, independent of the density of adults. Kvasnes et al. (2017) could not explain the differences based on vegetation types that appeared on existing digital maps. Later, Kvasnes et al. (2018) found that willow ptarmigans in August select slopes with vegetation types with dense field layers and marshes around the tree line; this is not particularly detailed. It is also not certain that the good habitats are always good. We have recorded that at Kongsvoll, a Mecca for bird dog sports and known for dense ptarmigan populations, the last decade has been quite devoid of ptarmigans with the result that hunting has been closed, while populations elsewhere have been high. Also, Barth (1891) writes about some years when ptarmigan were absent at Kongsvoll from the latter half of the 1800s. We do not know why such periods occur. We can speculate that some following years with poor reproduction and hard predation lead to such sparse populations that predators and hunters can take the entire surplus. In such cases, several successive years of good production and survival or immigration are needed before these can recover.

Then comes the anecdote that illustrates how difficult it is to know where there are many capercaillies or black grouse. No one knows more about these species than Professor Emeritus Per Wegge, after decades of research starting in 1979. He became jubilant, having leased bird hunting in the finest forest grouse habitat he had seen. After the hunt, he reported, somewhat crestfallen, that he had barely found any birds at all. It seems that many drivers override vegetation types, age distribution in forest stands, and logging methods. Our general impression is that Norwegian forests and mountains have plenty of food and space for far more forest grouse, but various drivers since the 1970s have pushed the populations far below what there is food for. Many researchers point to dense populations of small predators like martens and especially red foxes pressing the forest grouse populations down, and that the populations fluctuate at levels where there is little or no intraspecific competition for resources (Hjeljord & Loe, 2022; Wegge et al., 2022). When birds are shot, it does not lead to other birds surviving better or reproducing more (Wegge & Rolstad, 2023). When the populations of different forest grouse species in the same region in Norway fluctuate more or less synchronously, it suggests that overarching factors likely govern observed variation in reproduction and survival (Kvasnes et al., 2010).

FAST, R-SELECTED SPECIES

Grouse are, as a group, fast, r-selected species that can reproduce quickly—and reproduction can fail completely. Theoretically, if all survive, two willow ptarmigans can increase to over 200 after just three springs. Therefore, we should expect that the density of grouse species in autumn will vary greatly from year to year. It is fascinating that in the Evenstad study area, in autumn 2006, author Storaas and colleagues calculated from line transect data that there were about 26 capercaillie and black grouse per km^2. In the 40 km^2 area, there were around 1,000 forest grouse. In 2012, they calculated one bird per km^2, around 40 birds. The 2012 population was calculated to be only 4% of the 2007 population! Afterward, data indicated that the population quickly increased again. Hjeljord (2015) and Hjeljord and Loe (2022) reviewed everything written about the development of willow ptarmigan populations in Norway over time (Figure 13.1). With caveats concerning data quality, including variability in opening dates, Hjeljord and Loe (2022) concluded that ptarmigan populations have varied from low to very dense populations over time, but that the populations fluctuate around a much lower level with much lower peaks now compared to earlier, likely due to increased predation. Jahren et al. (2016) have found, overall, long-term declines in nest and chick survival of black grouse and capercaillie in Fennoscandia and that the link between predation, habitat loss and climate change remains unclear. Hazel grouse populations have been studied in Sweden but not in Norway, but there are strong indications that the population has declined in both countries during the past 30 years (Jansson, pers. comm; Statistics Norway harvest data).

Pedersen (1994) estimated that between ½ and 1 million pairs of willow ptarmigan attempted to nest each spring in Norway. If they lay 10 eggs each, between 5 and 10 million ptarmigans would die as eggs, chicks, or adults before the next spring, if the spring population is to remain constant. Of these ptarmigans, hunters harvest some 100,000. Millions die for other reasons. Shimmings and Øien (2015) suggested that the population in 2015 consisted of 150,000 to 250,000 pairs, far fewer than before, but still many. Various estimates fit the fast, r-selected life strategy. That a common game bird like the willow ptarmigan ended up on the Red List in 2015 (see Kålås, 2015) and was considered viable again on the 2021 list (Artsdatabanken, 2021) can also align with this life strategy. Listing the willow ptarmigan on the Red List was also a signal that more knowledge is needed about what governs the population development of ptarmigans (Kålås, 2015).

Wegge et al. (2022) analyzed 41 years of data from Varaldskogen east of Kongsvinger to see what factors influenced chick production in black grouse and capercaillie. They found that production varied with many factors. The strongest effects were chick food availability (larvae and bilberry production), small rodents, red fox density, the North Atlantic Oscillation (NAO) in winter, and temperature after hatching. Plenty of larvae and blueberries, many small rodents, few foxes, a cold and snowy winter and high temperatures after hatching resulted in good chick production. They write that the number of chicks in August "was correlated with factors that varied asynchronously and were not dependent on each other." They also note that the populations fluctuate at a low level due to persistent predation on eggs and chicks, especially from red foxes and martens. Grouse eggs and chicks constitute a small part of the diet for potential nest predators and chick hunters, but when many predators roam widely, many nests and chicks are found and taken quite by chance (Storaas et al., 1999). Eggs may appear more important for martens than for foxes, as martens store eggs for winter use (Willebrand et al., 2017), and marten predation on grouse nests remains quite high even in small rodent years, whereas fox predation decreases then (Jahren, 2017; Angoh et al., 2025).

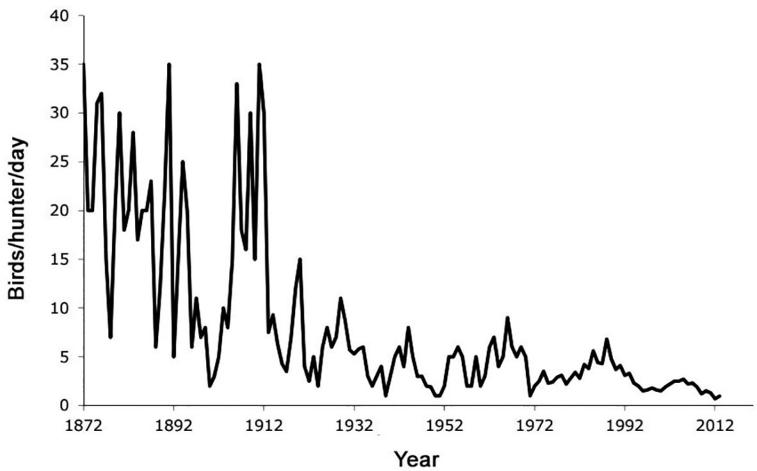

Figure 13.1: Estimated daily yield of willow ptarmigan for hunters in southeast Norway from 1872 to 2013. Although ptarmigan populations continued to cycle with vole fluctuations, there was a strong decline in amplitude after World War I. The hunting season generally opened three weeks earlier before the war. Figure from Hjeljord (2015).

Data from Varaldskogen suggest that after good, successive reproductive years, there are large losses of young capercaillie in winter due to predation (Wegge & Rolstad, 2011; Wegge et al., 2022). We can speculate that when there are good reproduction years for forest grouse, many young goshawks survive. If the next year is also good, there will be many experienced goshawks that can make significant impacts on the population of young forest grouse through the winter.

"GOD PLAYS THE SLOT MACHINE" HYPOTHESIS

The "God plays the slot machine" hypothesis is an imaginative way to explain the annual fluctuations in bird populations in certain areas. Here's a summary of the concept and related factors:

This hypothesis likens the factors influencing bird populations to a slot machine ("one-armed bandit") where each year, God pulls the lever, and various factors (represented by symbols in the machine's windows) align to determine the abundance of birds in the autumn. If all factors align optimally, bird populations flourish.

Factors influencing grouse populations:

1. **Adult population:** A sufficient adult bird population in spring is crucial. Hunting should be limited if the autumn population is less than desired in spring.
2. **Population density:** Extremely dense populations can spread disease and parasites, suggesting that hunting should target overly dense populations.
3. **Regional rejuvenation:** Good rejuvenation in the region encourages birds to settle in an area.
4. **Winter conditions:** Cold, snowy winters are favorable for forest grouse but challenging for foxes.
5. **Low winter predator presence:** Reduced raptor presence benefits bird survival.
6. **Limited winter food:** Scarcity of carrion and other food limits predator survival and reproduction.
7. **Available prey:** Abundance of small mammals and alternative food sources for predators during nesting season reduces pressure on birds.
8. **Low predator density:** Fewer foxes, martens and large raptors in the area are beneficial.
9. **Mild weather in breeding season:** Mild conditions in May, June and July support reproduction.
10. **Stable weather at hatching:** Avoidance of adverse weather during hatching is critical.

11. **Abundance of larvae:** Plenty of larvae in the heather provide essential food for chicks.
12. **Bilberry harvest:** A good bilberry year may enhance food quality for grouse and buffer against predation.
13. **Unknown factors:** There are likely additional unknown factors affecting populations.

Every year, God pulls the lever, and the wheels of the one-armed bandit spin around. Twelve of the wheels may show the right value, but it does not help if the thirteenth shows incorrectly. However, when all values are optimal, birds flourish. If the right values appear two or three years in a row, it can lead to an abundance of birds. But multi-year studies at Varaldskogen in the 1980s (Wegge & Storaas, 1990) and in Hedmark and Nord-Trøndelag in the 2010s (Jahren, 2017) have shown persistent high predation pressure on black grouse and capercaillie nests, especially from red foxes and martens, and most peaks in variation have likely been removed due to heavy predation (Wegge et al., 2022; Hjeljord & Loe, 2022).

Variable survival among adults and highly variable reproduction mean that birds can disappear from smaller areas. Forest grouse have a good ability to disperse (Hornell-Willebrand et al., 2014; Cayuela et al., 2019). In continuous forests and mountains, birds will disperse into empty areas, but capercaillie can easily disappear, and isolated populations have vanished from smaller patches of suitable habitat in Scotland (Warren et al., 2020) and elsewhere in the world (Storch, 2007). Locally reduced capercaillie populations may be augmented by birds dispersing in from neighboring and more productive metapopulations if there is adequate connectivity (e.g., Segelbacher & Storch, 2002).

Harvesting plans for forest grouse must take into account that populations vary greatly. The COAT project in Finnmark has for several years managed to predict the development of willow ptarmigan populations based on a model with fewer windows in the slot machine, where the result has come before line surveys are conducted (COAT 2023). Models that suggest the autumn population early are useful but certainly cannot be achieved until after surveying in August. Here, we remind the reader of complexity, change and randomness (see Chapter 8).

If someone wants to implement measures to influence the one-armed bandit, there are not many wheels or factors that can easily be manipulated: 1) In some places, it has proven possible to influence predators; 2) the most common approach is to regulate harvesting to ensure that hunting does not reduce the spring population more than managers desire. We will now discuss these two measures.

REDUCING PREDATION PRESSURE

When the Norwegian Association of Hunters and Anglers (NJFF) was founded in 1871, one of its main goals was to combat predators. Around the turn of the century, there was a significant effort against small predators and birds of prey. Forest grouse populations fluctuated around a very high level but collapsed in 1912. Over time, the perception arose that disease spread in dense ptarmigan populations was the cause of the decline (Søilen, 1995; Søilen & Brainerd, 1996).

Experiences from grouse moors in Scotland (Chapter 5, p. 123), fox-free hare islands in Northern Norway (Huseby & Bø, 1986; Pedersen & Pedersen, 2012) and the outbreak of mange in Sweden and Norway (Lindström et al., 1994; Smedshaug et al., 1999) show that red foxes significantly reduce small game populations. Studies of nest survival for capercaillie and black grouse show that foxes and martens take a substantial portion of the eggs (Jahren et al., 2016). An experiment on two small islands in the Northern Gulf of Bothnia in Sweden showed that martens and foxes negatively impact forest grouse production (Marcström et al., 1988). Jahren (2017) found in his doctoral thesis a correlation between the number of fox and marten tracks in an area in winter and the proportion of forest grouse nests that were preyed upon. Martens took many nests each year, while foxes took fewer in years with many small rodents. Today, most forest grouse researchers have noted that forest grouse do not die from old age or starvation but are predated, most of them taken as eggs or chicks. Egg predation among capercaillie and black grouse seems unaffected by the behavior of hens (Storaas & Wegge, 1997; Hagen, 2018). It is still reasonable to believe that the quality of food and thus the condition of the birds vary (Selås, 2019) and may influence predation on adults and chicks.

Predators can have a positive effect on prey populations. An article shows that wolves in an area play a positive role by taking wild boars with tuberculosis without reducing the wild boar population (Tanner et al., 2019). Ptarmigans in Norway also have parasites (Holmstad et al., 2005), but the densities of small game in Norway are usually too low for parasites to be perceived as a challenge compared to high-density areas of closely related red grouse in Scotland. Grant et al. (2012), in a report from the British Ornithological Society, show that a literature review indicates that predation can limit bird populations, especially ground-nesting forest grouse, waders and seabirds. Predation by introduced dingoes (wild dogs), red foxes and cats has eradicated many species in Australia, and many measures have been implemented to remove the introduced predators to protect Australian species. It is complicated, however; if managers remove dingoes, the fox population grows, and if they remove foxes, the cat population increases (Hunter et al., 2018).

Australians have extensive experience with how difficult it is to reduce red fox populations. Kirkwood et al. (2014) provide an example of how difficult it was to eliminate red foxes on a 100 km^2 island to prevent predation on the nests of ground-nesting birds, especially penguins. They used a bounty system for 30 years without success. For 25 years, they tried more intensive control measures without success. Only after hiring a very dedicated group of people who used poison extensively were they able to eliminate the foxes, and predation on nests decreased. On this island, it mattered little whether there were many or few foxes; the foxes that were there took penguin eggs. But it is easier to find eggs in penguin colonies than in sparse forest grouse nests scattered randomly.

Kammerle and Storch (2019) have reviewed all scientific publications on predator control to promote forest grouse populations. They conclude that results suggest that continuous predator control can benefit forest grouse if the control is well-planned and precisely executed. The question is whether predator control will have any effect on small game in Norway. Jahren (2017) found that martens and red foxes were the important predators of forest grouse nests. He found no evidence that corvid birds preyed on capercaillie or black grouse nests; instead, he captured images of capercaillies chasing away crows and ravens. Moa et al. (2020) found that red foxes, martens, weasels, crows and golden eagles preyed on willow ptarmigan nests, with red foxes being the most frequent and golden eagles the second most. Of adult willow ptarmigans with radio transmitters and known causes of death, Moa et al. (2020) found that about half were hunted or trapped, and half were taken by predators, with about half by predatory mammals and half by birds of prey.

In Norway, birds of prey are protected. Gjershaug et al. (2008) found that the populations of golden eagles have been stable since protection, and the reproduction of gyrfalcons has fluctuated with ptarmigan populations. In addition, there are floating populations of younger birds of prey searching for empty territories where they can establish themselves (Hunt 1998). The populations of birds of prey that take game species seem to be limited from the bottom up by prey availability.

It is likely that predator control works best after small rodent crashes when predators have little food and their populations are low. Predators will have few alternative food sources and will be more likely to enter traps, and each captured animal will represent a larger portion of the population. The effect will also be greater late in winter than in autumn. However, we emphasize that today we have too little knowledge about how predator pressure can be effectively reduced enough, in a cost-effective manner, to impact ground-nesters.

Since it is easier to trap martens than red foxes, martens are more specialized in eggs than foxes (Jahren, 2017), and since marten predation seems to be in addition to fox predation, managers often wish to prioritize marten trapping. Swedish researcher Vidar Marcström and colleagues (1988) were able to demonstrate that the experimental removal of both martens and red foxes from islands in the Gulf of Bothnia increased grouse populations. Although martens are trapped throughout Norway, with local bounties and even with permits in some places during the breeding season, there is little evidence to indicate that reducing marten numbers has much effect on forest grouse populations on the mainland.

The pine marten is most commonly associated with mature forests and may be negatively impacted by logging practices (Brainerd & Angoh et al., 2023). Pine marten predation on capercaillie nests decreases in areas with more agricultural land and roads and increases on a gradient from clear-cuts to deeper forest areas. Nest predation by red foxes predominates in more open landscapes (Angoh et al., 2025).

It should also be noted that when marten populations increased dramatically during an epizootic of sarcoptic mange that depleted the red fox population in Scandinavia in the 1980s (Lindström et al., 1995), forest grouse species and hares concurrently increased, with the exception of hazel grouse (Lindström et al., 1994). Since marten populations and small game populations increased in tandem, this may imply that martens did not fully compensate for red fox predation on these species. However, research conducted during this period indicated that the pine marten was an important predator on hazel grouse (Swenson, 1991), which may explain why numbers of this species did not increase during the epizootic.

Author Brainerd has conducted research on pine martens in Sweden and Norway for many years and was also an advisor to hunting clubs in Norway. He found that local managers encouraged marten trapping primarily as a measure to enhance grouse populations, but no one could demonstrate that it actually helped. This seems to be mainly primarily done as a “feel good” measure in most cases with little hope for measurable results. Pine martens are smaller and have less energy demand per unit area, occur in lower densities, and have lower reproductive rates than red foxes, and are themselves vulnerable to predation by foxes, lynxes and birds of prey. Only experimental marten removal over longer periods and larger areas will tell us whether control of pine marten populations will positively impact forest grouse populations at any scale, but this prospect is unlikely. Author Storaas is a grouse researcher and thinks killing martens could be good for grouse. Author Brainerd is a marten biologist and thinks it will probably not be particularly beneficial, even if marten populations are reduced locally. Both authors think killing red foxes could theoretically help, but that it is impractical since it is very difficult to effectively reduce populations through hunting and trapping at any scale.

HOW HUNTING AFFECTS PTARMIGAN POPULATIONS

The willow ptarmigan is the most studied grouse species in Norway, particularly with regard to population management. The long-standing belief was that hunting did not affect willow ptarmigan populations. Ptarmigan researcher Professor Johan B. Steen (1978) stated that there was reason to believe that around 10% of willow ptarmigans were shot and that hunting had not led to any significant reduction in willow ptarmigan populations, but he was uncertain. Aanes et al. (2002) used 34 years of survey and harvest data from an area in Sweden to calculate what could be harvested over time using different harvesting models. The estimated autumn population varied between around 800 and 2,600 willow ptarmigans. After thorough analyses, they suggested harvesting 50% of the estimated population, but no more than 600 birds in any year. Today, this seems like a very high harvest, and the quota would only be applied when the population is very high.

Based on data from a Norwegian hunting experiment, spring sizes of willow ptarmigan populations were similar between areas with no hunting and areas where 15% of the estimated population was harvested (Sandercock et al., 2011). However, harvesting 30% of the population did reduce the breeding population the following spring. Many willow ptarmigan managers set a quota of 15% of the estimated population based on these results. The challenge with the 15% rule is that hunters can easily harvest a larger portion of a small population but a smaller portion of a large one. It is easy to harvest 30% of a population with fewer than 10 willow ptarmigan/km^2 but difficult when there are more than 30 willow ptarmigan km^2. Thus, quotas are more crucial at low population densities.

In many countries, fixed quotas are commonly utilized to prevent overharvesting of small game. However, quotas are imprecise when the population size is unknown. Fixed quotas can be too high when populations are low and unnecessary when populations are high, which can potentially reduce harvests unnecessarily (Guthery et al., 2004a; Guthery et al., 2004b, Moa et al., 2017). Quotas can also level the playing field for hunters, benefiting those with less skill but disadvantaging skilled hunters with good dogs. Breisjøberget et al. (2018) found that in most Statskog areas in Nordland and Troms, less than 10% of ptarmigan populations were harvested, but hunting pressure exceeded 20% in some easily accessible areas. Most grouse management models rely on proportional or threshold harvest principles to estimate total allowable catch, but they often neglect uncertainty relative to the degree with which management goals are met (implementation uncertainty). This can lead to situations where regulations are overly restrictive when higher levels of harvests can be tolerated than are actually allowed by conservative regulations. Moa et al. (2017) address this issue and recommend greater use of tools like Management Strategy Evaluation (MSE) to test the robustness of harvest regulations under such uncertainty.

Hunting can influence the number of breeding ptarmigan pairs in the area the following year. It seems obvious that if there are fewer ptarmigans in autumn than desired in spring, hunting will reduce the spring population. If the population is very high and vulnerable to density-dependent diseases and parasites, hunting can reduce it to levels where this is not a concern. However, Norwegian ptarmigan populations are rarely if ever so dense that this is a concern. Most hunters aim to hunt every year, not to shoot as many birds as possible (Andersen et al., 2010). Therefore, hunting management should aim to ensure that autumn ptarmigan hunting does not reduce the breeding population to the point where it may not recover if predation is a major limiting factor.

Further research is needed using modern technology to better understand the effects of hunting on ptarmigan populations, and particularly rock ptarmigan which have not been studied nearly as extensively as willow ptarmigan.

MANAGING PTARMIGAN WITH AND WITHOUT SURVEY DATA

When the size of the population is unknown, precise management is challenging. It seems that Norwegian authorities have considered this when setting hunting seasons. Ptarmigan and other grouse species usually hold well for dogs, providing good shooting opportunities into September (Barth 1891). In October, and especially in November and December, fewer grouse are harvested (Mathiesen et al., 2023). Grouse species were included in hunting laws in 1863 with a season starting from August 15. In 1900–1901, hunting began on September 15, with varying start dates in subsequent years between August 25, September 1, September 10 and September 15, until it settled on September 10 in 1988 (Hjeljord, 2015). The highest harvest numbers were during the years with earlier starting dates. We perceive season starting dates as a compromise between being able to hunt birds that hold for the hunter and dog and preventing the overharvesting of populations of unknown size.

It is easier to manage a population when there are good data on population size and reproduction. In 2020, willow ptarmigans were surveyed using dogs and the distance method in nearly 200 areas, and the Grouse Portal[1] calculated the density. Landowners who want their area surveyed can have it done. Andersen and Thorstad (2013) proposed that a landowner could define how many breeding birds they want on their property in spring to use as a metric for setting fall quotas

1 https://honsefugl.nina.no

such that there is a minimum number of birds that should remain at the end of the hunting season. This strategy is referred to as threshold harvesting, where managers designated a population level, or threshold, above which a surplus of birds can be harvested (Engen et al., 1997; Lande et al., 1997; Hiker & Liz, 2020). The threshold, also known as escapement or biomass reference point in fisheries management, represents the population level left untouched by harvesting. Threshold harvesting keeps the population at a constant ceiling, contrasting with constant quota harvesting, which removes a fixed number of individuals. Proportional harvesting, taking a constant fraction of the population, serves as a middle ground between these two approaches (Hiker & Liz, 2020).

Thresholds for ptarmigan harvest quotas will vary between areas based on density. In many areas, fall densities vary between less than 10 to over 30 ptarmigan per km^2 (Pedersen & Storaas, 2013a). If there are 40 ptarmigans/km^2 in a 10 km^2 area and the goal is a post-hunt density of 20 birds/km^2, then theoretically half of the 400 ptarmigans could be harvested. This is an unrealistic scenario in Norway, however, as we have never seen anything like that level of harvest in a dense population. Threshold harvesting is more appropriate for preventing overharvest of small populations that can be easily overharvested, but less so where hunters are unlikely to harvest the entire surplus.

One option is to close seasons in years where there are few ptarmigans. Breisjøberget et al. (2017) found that most ptarmigan hunters supported closing an area to hunting if it could allow populations to increase; however, they indicated that they preferred to hunt for the recreation value, and harvesting was a secondary priority. Very low quotas in areas with poor ptarmigan numbers could allow the keenest hunters to recreate without greatly harming the population. Lost hunting opportunities in such situations might be compensated by fewer bad years and even better hunting when populations are stronger. Another challenge might be that local protections lead to increased hunting pressure in open areas. But this could benefit protected populations, if indeed older males attract young males and females into the area (Kvasnes et al., 2015).

Statskog is a major player in ensuring sustainable game management on its properties and practices adaptive management of ptarmigan populations (Sandercock et al., 2011; Breisjøberget et al., 2018). They conduct distance line transect surveys to assess densities and chick production in August prior to the season start. They use a threshold strategy based on chick production and hunting pressure as key indicators regarding whether or not a hunting zone can sustain harvest or not in a given year. The key parameter is chick production, for which they have set a minimum of 2.5 chicks per pair as a threshold for management decisions. Production under this threshold is considered unsustainable. Consistent harvest pressure under 5% is considered sustainable whereas a threshold of 15% is considered unsustainable, even with chick production above 2.5 chicks/pair.

Statskog has a three-tiered management system for hunting zones based on a traffic light system of red (closed), yellow (regulated) and green (open) zones based on these thresholds. Zones are classified as red if production is under 2.5 chicks per pair as there is no harvestable surplus. If the production threshold is above 2.5 chicks/pair, hunting is permitted. In green zones, harvest has not exceeded 5% in the last five years, and the zone is open to permit sales. In yellow zones, the harvest has exceeded 5% in recent years, and the zone is open to permit sales but is regulated and harvest is closely monitored. If more than 15% of the population was harvested last year, the number of hunting days in the terrain is limited in the following year. There are no quotas, but the number of hunters is limited to five hunter days per zone with a maximum bag limit of four ptarmigan a day. Hunters must report their harvest.

The mountain board in the municipality of Lierne in Trøndelag county has made a detailed management plan for ptarmigan hunting (Åberg, 2017). The plan allows for adjusting harvest percentages and quotas based on surveyed grouse population size. They wisely use low harvest rates for low densities and higher rates for high densities. Management options also depend on whether hunting areas are open to permit sales to the general hunting public or are privately leased. Combining threshold harvesting with quotas and hunter-density restrictions is possible. Landowners must decide the number of hunters allowed in the area at any time, keeping in mind that fewer birds are typically harvested later in the season. More studies on hunted populations, like in Lierne where Israelsen et al. (2020) tracked 188 radio-tagged ptarmigans, are needed for better insights.

SUMMARY OF PTARMIGAN MANAGEMENT

The book *Rypeforvaltning* ("Ptarmigan management") summarizes lessons from the Ptarmigan Management Project (2006–2011), including new knowledge gained since then (Pedersen & Storaas, 2013b). Here are key points:

1. **Regulation and hunting practices:** The Environment Agency sets hunting seasons. Within these, landowners can allow hunters to harvest as many grouse as possible using shotguns limited to two cartridges.
2. **Landowner objectives:** Different landowners have varied goals. Statskog, Fjellstyra and many others focus on accessible hunting for the public, while some prioritize economic returns and creating local economic value (Andersen et al., 2010).

3. **Hunting patterns:** Generally, forest grouse hold well for dogs in August and early September, becoming warier later (Mathiesen et al., 2023). Most grouse are harvested during the first few weeks of the season, with a few taken later in the fall.
4. **Behavior of ptarmigan:** Older males tend to hold their ground better later in the season, making them more vulnerable. It is believed (though not confirmed) that surviving older males attract young males and females to the area at normal densities (Kvasnes et al., 2015). Thus, it may be beneficial if neighboring areas harvest older males but may be detrimental to one's own property.
5. **Impact of hunting:** Hunters tend to harvest a larger portion from low-density populations than high-density ones. This means hunting can have a more significant impact when ptarmigan numbers are low (Breisjøberget et al., 2018, Eriksen et al., 2018).
6. **Hunter preferences:** Ptarmigan hunters value recreation over bagging many birds, preferring to avoid poor years rather than seeking large populations. However, most hunters do not achieve what they consider to be reasonable bag limit quotas (Andersen et al., 2013; Breisjøberget et al., 2017).
7. **Preventing overharvesting:** Various methods are suggested, including quotas and limiting hunting efforts, such as hunter density (hunter days/km^2). In Sweden, the rule is that less than three hunter days per km^2 allows ptarmigan to tolerate hunting pressure. Swedish hunting starts on August 25, and few ptarmigans are harvested after mid-September when they become harder to shoot.
8. **Quotas in poor years:** To be effective, quotas must be very low in poor years, as most hunters will not bag many birds anyway (Breisjøberget et al., 2018).

CAPERCAILLIE AND BLACK GROUSE MANAGEMENT

During meetings on grouse management, questions often arise about whether female capercaillie and black grouse should be protected, and public proposals suggest extending the hunting season for male capercaillie and black grouse into January. Although scientific studies on this topic are lacking, we discuss it due to widespread interest.

We lack definitive knowledge on the impact of protecting female birds. Older females tend to nest in the same area year after year, while many young females will leave the hunting area, with young birds from neighboring areas moving in. For protection to be effective, large neighboring areas should also protect female birds. It is reasonable to think that hunting female birds has no impact when populations are large but matters when there are fewer females in autumn than desired in spring. Wegge and Rolstad (2023) recommend cautious harvesting with moderate or better chick production and protecting female birds when production is low. Protecting females when populations are low seems wise, as there are likely enough males for mating regardless, so protecting males is not necessary. Old capercaillie and black grouse males are difficult to hunt with a shotgun, usually requiring a skilled hunter, excellent dogs and luck. Without survey data, managers can allow annual hunting of males but base female hunting on general impressions. If the general impression by September 1 is that there are few birds and small broods, females can be protected. Otherwise, female hunting can be open. This approach is not precise science but is likely better than having the same rules every year.

However, Statskog has recently used the following approach for managing capercaillie and black grouse on their properties (J. Hagen, pers. comm.).

- No open season when production falls under 0.8 chicks per capercaillie hen or 1.2 chicks per black grouse hen.
- No hunting of female capercaillies when production is between 0.8–1.1 chicks per capercaillie or 1.2–1.5 chicks per black grouse hen.
- When production is above these numbers, no more than 10–20% of the estimated population for either species should be harvested.
- Limitations on hunting pressure are also being implemented (maximum five hunter days per zone[2]).

Statskog and the Norwegian Institute for Nature Research are currently collaborating on a large-scale experimental research project to test different harvesting regimes for capercaillie, black grouse and willow ptarmigan on its properties based on monitoring of populations and manipulation of harvest levels[3].

Capercaillie and black grouse can be hunted with a rifle if the landowner permits it. Snow-covered trees, plowed forest roads providing access, and suitable conditions for walking or skiing create ideal conditions for hunting dark capercaillie males and black grouse perched in snow-covered treetops—known as “top hunting”. Jonas Hagen (2020) collected capercaillie for his master’s thesis through top hunting and managed to harvest 19 capercaillies over 32 days, averaging 0.6

2 Zone sizes vary relative to topography and habitat.

3 https://www.statskog.no/jakt-og-fiske/baerekraftig-forvaltning/hostingsprosjektet-2025-2027-for-rype-og-skogsfugl/hostingsniva-og-fangstrapportering

per day. He noted that success depended heavily on conditions and hunting in areas where capercaillie congregate in winter. He once harvested four capercaillies in a day and could have taken more. With today's low chick production (Wegge et al., 2022), adult survival is crucial, and survival rates appear to be increasing (Jahren et al., 2016). Extending top hunting to February 15, as in Sweden, could reduce adult male survival in years with favorable hunting conditions. However, conditions are rarely perfect, and a capercaillie can mate with many females, so it is unlikely females in continuous forests will not be able to find mates.

A challenge is that males from large areas may gather in specific feeding grounds, affecting breeding populations on other properties and making it difficult to set low quotas at the property level. Landowners lack data for setting quotas, which would need to be established at the regional level by higher authorities based on autumn surveys and hunting reports, leading to uncertainty.

Unfortunately, there is little data on the impact of winter hunting on capercaillie and black grouse, leaving room for speculation. Likely, top hunting in January after years of good production could provide enjoyable experiences for hunters without significantly affecting populations. Conversely, after years of poor production, January top hunting could be detrimental. Wegge and Rolstad (2023) suggest top hunting is additive since males are taken in winter. Barth (1881b) described hunters teaming up to find and nearly eliminate flocks. He believed capercaillie provided better and more challenging sport in autumn. Fewer males at breeding leks in spring could reduce options for females, potentially affecting evolutionary dynamics and diminishing the experience for those observing leks. Without data on top hunting's impact in January, a precautionary approach suggests ending top hunting by Christmas until more knowledge is gathered and analyzed.

ROCK PTARMIGAN AND HAZEL GROUSE MANAGEMENT

Rock ptarmigan and hazel grouse do not hold well for dogs and are less studied in mainland Norway compared to other grouse species. The rock ptarmigan is well-studied in Iceland and Svalbard, where it is the only grouse species. Globally, some rock ptarmigan populations have increased, some are stable and others have declined (Fuglei et al., 2020). Populations fluctuate significantly, and while rock ptarmigan in Norway were previously on the Red List, they are no longer (Stokke et al., 2021a). A study with radio-tagged rock ptarmigans showed that over half of the birds died from February to July, and they can migrate long distances from winter to breeding areas, with an average distance of nearly 20 km and the longest nearly 80 km (Nilsen et al., 2020).

In Svalbard, ptarmigan densities are recorded using distance measurements from points (Pedersen et al., 2012). Author Brainerd first suggested this method at a meeting with the Governor of Svalbard in 1999. There is a lack of good rock ptarmigan habitat there, and territory-less birds took over territories when territorial birds were harvested (Pedersen et al., 2014). Surveying rock ptarmigans with dogs is challenging because hunters often find that they run on the ground during hunts, making it difficult to know where they were when they detected the dog and observer. Author Brainerd appreciates that Rogaland JFF still limits rock ptarmigan harvests in Rogaland terrain based on distance measurements with dogs and a management plan that he and Leif Kastdalen created in 2001. Users seem to find the method effective enough[4]. Rock ptarmigans hold better in August than in September, and in open terrain, observers usually see the birds before they start running. Since much rock ptarmigan terrain is remote and rugged, laying representative survey lines is difficult, and many populations are hard to survey before hunting. There is ongoing research in Sweden and Norway to test distance line transect surveys as a suitable method, and preliminary results are promising.

Snow melts from the bottom up the mountain, allowing willow ptarmigan to reproduce before rock ptarmigan. However, it has been shown that the harvest and likely production of both species roughly correlate in Norwegian counties (Kvasnes et al., 2010), so willow ptarmigan surveys can provide an uncertain indication of rock ptarmigan production. With a quick r-selected species living in vast mountain areas, it is hard to imagine autumn hunting significantly impacting rock ptarmigan populations. Nilsen et al. (2020) found that 9% of the radio-tagged birds were harvested during winter hunting in February. More studies with radio-tagged rock ptarmigans are needed. We know they are no longer on the Red List and live in large areas high in the mountains. Until more knowledge is gained, they seem to be manageable under current hunting seasons, typically without quotas. Here it should be mentioned that a recent study from Iceland indicates that the highly cyclic rock ptarmigan populations sustain harvest, but that there is a need for better regional management based on an adaptive management approach since population dynamics and hunter priorities vary (Johnson and Nielsen, 2024). One of author Brainerd's professors and important mentors, Bob Weeden, was a pioneer in rock ptarmigan research and management, and found that heavy hunting pressure could lead to overharvesting along a road system in interior Alaska (Weeden, 1963, 1972).

4 https://www.statsforvalteren.no/siteassets/fm-agder/dokument-agder/miljo-og-klima/viltforvaltning/rype-takseringsrapport-agder-2016.pdf

Hazel grouse live in territorial pairs in the forest. The number of hazel grouse hunted has declined, with only a few thousand taken annually (Statistisk sentralbyrå, n.d.). The situation is similar in Sweden (Gunnar Jansson, pers. comm.). It is unclear whether this decline is due to a decrease in population or reduced hunting interest, although monitoring at the Grimsö research station in Sweden may indicate declining populations (Jansson, pers. comm.). The Norwegian Biodiversity Information Center considers the hazel grouse to be viable (Stokke et al., 2021b). Doctoral research by Swenson (1991) and Åberg (2000), based on fieldwork in good hazel grouse habitats in Sweden and Finland, provides insights into hazel grouse biology. Hazel grouse are closely associated with dense spruce stands mixed with deciduous trees, especially alder. Hazel grouse depend heavily on alder for food, and its presence is essential. Dense regenerating spruce stands that are at least 40 years old, or natural uneven-aged spruce-dominated stands, are good habitats as long as alder is available. Alder trees greater than 5 meters from cover are not used due to predation risk. Trees should be at least 10 meters tall, and they favor openings with dense ground vegetation. Territories are 10–20 hectares, and larger patches of suitable habitat close to continuous forest are more likely to host hazel grouse. The goshawk is a significant predator of hazel grouse. They do not hold for dogs and are mainly hunted using a whistle call that mimics the sounds of territorial males that will respond to defend their territory. Since there is a surplus of male hazel grouse, whistle-call hunting of males appears to be sustainable (Swenson & Brainerd 1998). Promoting larger mixed stands of spruce with closely associated alder seems beneficial for hazel grouse. Since there are indications that hazel grouse populations are declining on the Scandinavian Peninsula, more research is needed. Until now, the only research on this species in Norway has been through student projects supervised by Torfinn Jahren and author Brainerd at Evenstad.

AUTHORS' REFLECTIONS

Grouse populations are doing relatively well, although there have been longer-term declines for all five species in Scandinavia. Predation seems to be an important driver of these declines, but habitat loss, pollution, and climate change may also be factors. Hunting may be compensatory or additive, depending on the population and year. Autumn populations are influenced by many factors that vary asynchronously, most of which are beyond managerial control. The simplest approach is to survey populations and reduce hunting pressure or protect populations when they are low. Protection may not increase populations but hopefully prevents them from declining so much that predators take all the production and keep populations suppressed. Red foxes thrive in landscapes modified by human activity, and together with martens, these predators can exert strong predation pressure on forest-dwelling grouse species. However, predator control is expensive, and outcomes are difficult to measure. In addition, protected avian predators also can have strong influences on grouse populations. Thus, it is difficult to limit predation on grouse populations effectively.

The flight distances of grouse species increase through the fall hunting season, and many birds escape by flushing quickly out of shooting range (Barth, 1891; Mathiesen et al., 2023). In Sweden, forest grouse hunting starts on August 25. The hunting law committee leading up to the 1951 Hunting Act proposed starting grouse hunting on September 20, with provisions allowing the game board to advance the start by up to five days under certain conditions (Ministry of Agriculture, 1951). Today, the forest grouse hunting season could start on September 10, but with surveying, quotas and threshold hunting, it could be advanced to September 1. This would provide nine more days of hunting birds that hold for dogs in good years but allow protection in poor ones (Mathiesen et al., 2023). The quota would apply to the specific terrain. Grouse can move to other hunting areas in winter, but few are hunted during this season.

We have substantial knowledge about Norwegian grouse species, but large-scale experiments are needed to test hypotheses, especially concerning hunting and reducing predation, without excessive costs and in line with current ethical standards. The work Statskog is conducting on scientific, adaptive management of grouse species should inform strategies in the future.

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14. Other game species in Norway

There are 40 species of native game species and 16 invasive species that can be hunted in Norway (see Appendix 1). In addition, three threatened large carnivore species are occasionally culled (see Chapter 15). Deer and grouse species are the most important game species in Norway; harvests of the other native small game species are relatively limited and, in most cases, do not affect populations (Pedersen et al., 2021d).

In this chapter we discuss the management of mountain hares, once a significant game species that led to the development of three Norwegian hare hound breeds. It also covers the management of seabirds and waterbirds, which have been important food sources since the Stone Age (Hjelle et al., 2006). However, during the past 30 years most seabird species have been removed from the list of huntable species, except for the two cormorant species. The European golden plover (*Pluvialis apricaria*) and the redwing (*Turdus iliacus*) were recently removed from the list of game species due to declining populations. Geese populations have grown significantly in recent decades, prompting management and hunting plans to keep them from harming habitats or agricultural crops. Beavers were once so sought after that they were nearly exterminated from the Scandinavian Peninsula; today, management practices vary depending on the municipality. Many wood pigeons (*Columba palumbus*) are hunted, and woodcock (*Scolopax rusticola*) hunting is favored by some hunters. To maintain interest in hunting less popular game species, it is crucial that managers and landowners provide opportunities and information.

MOUNTAIN HARE

Mountain hares are widespread across Norway, from the south to the north and from coastal to alpine habitats. Hare research has been lacking, with much knowledge based on various observations (Barikmo & Pedersen, 1997). Besides grouse species, mountain hares were the most important game in the late 1800s (Barth 1891), and photos exist of King Haakon VII and Fridtjof Nansen hunting hares with baying hounds (Schjøll, 2021). While big game populations have increased, mountain hare hunters have declined. The mountain hare is now red-listed in

Sweden and Norway due to significant population declines (Eldegard et al., 2021b). We know that mountain hares responded positively and dramatically to a natural decline in red fox populations on the Scandinavian Peninsula in the 1980s and 1990s (Lindström et al., 1994; Smedshaug et al., 1998), but the species declined again after the fox population recovered. In Southern Sweden, mountain hares are threatened by the invasive European hare (Thulin et al., 2021), which has spread to the region of Østfold and Akershus in Southeastern Norway and may eventually spread along Norway's southern coast (Pedersen et al., 2018).

In Norway, heavy grazing pressure from roe deer may negatively impact mountain hares (Hulbert & Andersen, 2001), while moose grazing likely does not, though more studies are needed (Pedersen & Pedersen, 2021). Newey et al. (2007) found that some hare populations in the UK were limited by disease, but predation is the main limiting factor in Scandinavia, despite sporadic outbreaks of tularemia affecting populations. Predation is exacerbated by shorter winters and snow cover, particularly in areas with many predators (Pedersen et al., 2017; Stokes et al., 2023). On fox-free islands in Northern Norway, mountain hare populations are dense (Huseby & Bø, 1986; Pedersen & Pedersen, 2012).

Barikmo and Pedersen (1997) describe measures to improve mountain hare populations, suggesting that while hunters might enjoy implementing these measures, they are unlikely to help wild hare populations. Breeding and releases on the mainland provide food for foxes. Releases on fox-free islands have led to dense hare populations, but permission is required for new island releases. Barikmo and Pedersen (1997) have little faith in supplementary feeding, fertilization, protection and building shelters for mountain hares. Reducing red fox populations would help hares, but as stated in the last chapter, this is difficult. Hunting appears to have no impact on mountain hare populations, but if few young hares and many old ones are shot, local managers should close hunting.

Hare hunting with dogs has been common in Southeastern Norway, where wolves are now present. Wolves can kill dogs, especially baying hunting dogs that range far from their owners (Haidt et al., 2021; Kojola et al., 2022), which has led to many hunters now refraining from hunting hares with dogs in wolf territories. Pedersen et al. (2019) found that hunting for hares and other small game hunting declined dramatically in wolf territories with significant negative impacts on rural economies. Managers may be able to market hare hunting with dogs in some areas with abundant populations and a lack of predators, such as is the case on islands in Northern Norway.

We conclude that little can be done to enhance mountain hare populations on the mainland unless red fox populations can be somehow reduced, since we are unable to control other factors. Pedersen (2023) emphasizes the need for more research, calling for improved monitoring methods and studies on how climate change, hunting, competition from other herbivores, land-use changes, predation and parasites affect populations.

BEAVER

Due to valuable pelts and beaver gland usage in medicine, beavers were eradicated in Sweden by 1871, and in Norway, only a remnant population of perhaps 100 animals remained in Agder and Telemark by 1899 (Rosell & Pedersen, 1999). The beaver was first protected by law in 1845 in Norway. Protection in Norway and reintroductions in Sweden have allowed beavers to spread across the country. The hunting season in 2024 ran from October 1 to April 30 to avoid hunting mothers with dependent kits. Most beavers are hunted in spring. The University of South-Eastern Norway has acquired extensive knowledge about beavers (Rosell & Pedersen, 1999; Rosell & Campbell-Palmer, 2022). Rosell et al. (2006) surveyed 53 one-square kilometer plots, finding lodges on foot and assessing their usage based on the dam and lodge maintenance, recently cut vegetation, recently used canals and paths, fresh tracks and scent markings. They found an average of 3.8 beavers per lodge. The simplest way to assess a beaver population in an area is to count active lodges and multiply by four individuals per lodge (Parker et al., 2002). Rosell and Campbell-Palmer (2022) found it most probable to shoot pregnant females and adult males during spring hunting, potentially dampening population growth. If high production is the goal, hunting only certain colonies and sparing others may be beneficial, as this strategy only targets animals near lodges. With spring hunting, populations can remain stable when 10–20% of individuals are shot. In an experiment, Parker and Rosell (2014) annually shot 24% of beavers in a 242-km^2 area, reducing colony numbers to nearly half after three years. When beavers were protected, active lodge numbers returned to pre-hunting levels after four years. The authors noted in lectures that achieving a 24% harvest required significant effort and that hunting pressure is typically much lower. Thus, beavers usually do well without the need for rigid management plans. According to beaver regulations, municipalities decide whether to implement management plans, which are often not a high priority unless there are conflicts with beavers due to flooding or tree damage.

SEABIRDS

Seabirds primarily live along coastlines, islands and open oceans. They spend much of their life at sea, often far from land. They typically feed on marine life such as fish, squid and crustaceans. Common seabirds include gulls, puffins, terns, albatrosses, petrels and cormorants. Many seabirds have adaptations for long-distance flight and diving, such as streamlined bodies and specialized beaks.

Norway has a long tradition of seabird hunting on the sea and fjords. In the 1980s, many seabird species were classified as huntable game species, including Eurasian oystercatcher (Haematopus ostralegus), black-headed gull (*Chroicocephalus ridibundus*), European herring gull (*Larus argentatus*), common gull (*Larus canus*), great black-backed gulls (*Larus marinus*), black-legged kittiwake (*Rissa tridactyla*), Atlantic puffin (*Fratercula arctica)*, common murre (*Uria aalge*), thick-billed murre (*Uria lomvia*), razorbill (*Alca torda*) and black guillemot (*Cepphus grylle*). However, all of these seabird species have significantly declined in recent years, and at present none of these are listed as game species. Some gull species were classified as game birds up until 2016; however, it is still possible to gather eggs from European herring gulls, lesser black-backed gulls (*Larus fuscus*) and great black-backed gulls with some restrictions.

The causes of these seabird declines are often difficult to determine, potentially involving increased predation on adults, eggs and chicks, reduced food availability or changing weather conditions (Layton-Matthews et al., 2024). Human-related factors such as fishing, pollution, oil spills, hunting or tourism may also play a role. Causes can vary by location and year, but climate variables have been shown to explain many differences in breeding success and survival. Established in 2005, the SEAPOP research program[1] conducts comprehensive and long-term monitoring and mapping of Norwegian seabirds, aiming to distinguish changes caused by human interventions from natural fluctuations. Their website provides up-to-date seabird information.

Seabirds often breed in one location and spend the rest of the year elsewhere, with different populations having various, sometimes overlapping migration routes. It is crucial to protect populations that cannot withstand hunting and only hunt those that can. The international SEATRACK[2] project maps migration routes and wintering areas for seabirds in the North Atlantic.

Among Norwegian seabirds, only the cormorants remain classified as game species: the great cormorant (*Phalacrocorax carbo*) and the European Shag (*Gulosus aristotelis*). Conflicts with the fishing interests occur for both species, and sometimes they are felled by special permits to reduce depredations on fish stocks. There are two subspecies of great cormorant in Norway. The subspecies (*P. c. carbo*; known as “Storskarv” in Norwegian) breeds along the Norwegian coast from Trøndelag to Finnmark[3]. The breeding was estimated to be around 42,000 indi-

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1 https://seapop.no/

2 https://seatrack.net/

3 https://artsdatabanken.no/Pages/186784

viduals in 2014 (Anker-Nilssen et al., 2015). In Finnmark and Troms as well as in Røst, Nordland, the populations seem relatively stable from 1992 to 2019. However, in Trøndelag and Nordland the population declined by 50% from 1992 to 2019 (Fauchald et al., 2015) and thus was classified as Near Threatened by the Norwegian Biodiversity Service. Because of its status, hunting is only allowed for juvenile birds with white bellies in saltwater locations. The subspecies *P. c. sinensis* ("continental cormorant", or "Mellomskarv" in Norwegian) became established in Southern Norway in 1997. It is more associated with brackish water and freshwater and tends to nest in colonies in trees, along the coast from Østfold to Rogaland. Birds from Northern Europe often overwinter around the Mediterranean. The Norwegian breeding population is estimated at about 5,000 individuals (Shimmings & Øien, 2015) and has increased in Norway since it was established (Norwegian Biodiversity Service). Due to its success, hunting is open for both young and old birds in freshwater regions. The European Shag breeds in Norway, scattered across outer coastal areas along the entire Norwegian coast. It nests in colonies in rock crevices or boulders and feeds on fish. Birds that breed in Norway overwinter along the Norwegian coast. The Norwegian breeding population was estimated at around 56,000 individuals in 2014 (Anker-Nilssen et al., 2015). The assessment period for European Shag is 27 years (due to the species' generation length of nine years (Bird et al., 2020)). Data from the national seabird monitoring program/SEAPOP shows that colonies of European Shag have generally had stable populations or shown an increase from 1992 to 2019, although it has completely disappeared from the seabird colony at Runde, where it was common 30 years ago (Fauchald et al., 2015). Overall, the species is listed as a species of Least Concern on the Norwegian Red List, although it has been declining in Europe[4]. It can be hunted in central and Northern Norway from Trondheim fjord northwards.

WATERBIRDS

Waterbirds are found in freshwater environments such as lakes, rivers, wetlands and marshes, as well as some coastal areas. They are usually migratory. Their diet can include fish, insects, aquatic plants and small amphibians. Common waterbirds include cranes (*Gruidae*), ducks, swans and geese (*Anatiformes*). They are adapted to swimming and wading.

For waterbirds, only two goose species and nine duck species native to Norway are classified as game species (see Appendix 1). Hunting is directed toward viable populations through geographic restrictions and hunting seasons. For example,

4 https://lister.artsdatabanken.no/rodlisteforarter/2021/27691

hunting black scoters (*Melanitta nigra*) in Østfold is allowed because they belong to a larger Swedish population. Hunting of eiders (*Somateria mollissima*) has been controversial due to their population status and the fact that it is considered a domestic bird valued for its down in Northern Norway. Only male eiders can be harvested in Southern Norway, and quotas allow a hunter to take up to five birds per day and no more than 25 per season.

In Denmark and Sweden, managers commonly create wildlife ponds and release mallards (*Anas platyrhynchos*) for hunting on properties, although Denmark's Hunter Association plans to phase out farm-raised ducks (Kirkemo, 2023). Sweden is focusing on creating favorable conditions for wild ducks (Jägareförbundet, n.d.). In Norway, releasing ducks for hunting is illegal, but wildlife ponds without releases can benefit many species. Feeding in wildlife ponds along mallard migration routes can increase harvest rates, with important pauses between hunts.

The populations of cranes, geese and swans have increased in Europe due to protection, reserve establishment, and improved foraging on fertilized, productive agricultural land in wintering areas. The damage to farmland is substantial, and one solution could be designating areas where birds can graze undisturbed (Montras-Janer et al., 2020). In many cases, measures to reduce populations are necessary (Montras-Janer et al., 2019), although cranes and swans remain protected.

In Norway, grazing damage from geese is problematic. Goose management is complex, as some species are divided into subpopulations that share winter areas but have different or similar migration and breeding areas. For example, the barnacle goose (*Branta leucopsis*) migrates from three breeding areas along three corridors in Western Europe. Managing geese requires international cooperation, with international management plans for the pink-footed goose (*Anser brachyrhynchus*; Madsen & Williams 2012), barnacle goose (*Branta leucopsis*; Jensen et al., 2018) and greylag goose (Powolny et al., 2018).

For the pink-footed goose on Svalbard, a population target of 60,000 individuals has been set. The plan involves maintaining this target through adaptive management with surveys and facilitating hunting (Madsen & Williams, 2012). Hunting is initially focused on migration areas in Norway and wintering areas in Denmark. When the population exceeds the target, measures to increase harvest are implemented. When it falls below, hunting pressure is reduced, and quotas are allocated among countries. Goose hunters find this approach sensible (Tombre & Gundersen, 2022).

Tombre et al. (2013) describe how farmers in Vesterålen successfully reduced conflicts arising from migratory geese grazing on their fields in spring. Populations of pink-footed and barnacle geese, which breed in Svalbard, had increased significantly over recent decades. During their northward spring migration, they stopped to graze on well-managed grasslands in Vesterålen before flying over the sea to their breeding sites. The grazing impacted farmers differently depending on the attractiveness of their land to the geese. The problem grew so large that systematic efforts to haze geese began in 1993, which worked but required significant effort. Tombre et al. (2013) illustrate how local farmer associations initiated and succeeded in raising grazing damage as an issue, gathering stakeholders and ultimately establishing a compensation scheme funded by the Ministry of Agriculture and Food. The scheme is based on voluntary agreements with farmers who pre-approve geese grazing on defined fields in exchange for compensation. This has reduced conflict levels despite increasing goose populations.

Jensen et al. (2016) collaborated with local stakeholders in Trøndelag to find the best hunting methods. Geese are most effectively hunted when landowners and hunters work together across large areas. Hunting should occur in the morning using decoys but not more frequently than every third day at the same location. There should be at least 3 km between simultaneous hunting parties, hunting locations must rotate, and refuges without hunting must be available for geese. Based on research, both state administrators and municipalities have developed goose management plans. Hunters in Trøndelag were positive about recording, reporting, and participating in management to keep the pink-footed goose population at its target level (Holmgaard et al., 2018). If hunting does not stabilize the population, capturing birds during molting and killing them with gas, as done in some countries, may be necessary (Gerritzen et al., 2013). Goose management is an example of effective adaptive management, where ordinary hunters play a crucial role (Tombre et al., 2022).

AUTHORS' REFLECTIONS

Accessing hunting for big game and grouse can be expensive and challenging. If the goal is to recruit more hunters, it is important to provide access and information regarding less popular game species. Improved monitoring and increased knowledge of various species, particularly the decline in hare populations, would be beneficial. Otherwise, the harvest levels appear so low that hunting likely has little impact on hare populations. The hunting of pink-footed geese aims to maintain the Svalbard population at 60,000 individuals. From 2018 to 2022, between 2,120 and 4,760 pink-footed geese were harvested annually. Despite cooperation and good organization, it seems challenging to keep the population at the target without additional measures in the wintering areas.

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15. Predator management

Managing predators, big or small, is challenging. Here, we will first examine changes in attitudes toward predators from 1845 when a law was passed that aimed to eradicate them until the current situation and conflicts. We will discuss key principles for large carnivore management before focusing on individual species; we will also discuss the management of smaller predators. Finally, we will offer some general reflections on predator management.

ATTITUDES TOWARD PREDATORS

Opinions and attitudes toward carnivores have varied across time, geography, cultures, and among individuals. In 1845, the Norwegian Parliament decided to eradicate wolves, bears, wolverines and lynxes, as well as golden eagles, white-tailed eagles, goshawks and eagle owls. They were largely successful in eliminating large carnivores, which could allow livestock to freely roam without shepherding. This shift enabled the transition from predator-adapted sheep that flocked together to less adapted breeds that spread across the summer range and better utilized forage. Large carnivores were protected in the early 1970s, and since that time conflicts with the livestock industry have increased. Sheep graze freely in forests and mountains in Norway, and losses are much higher than in other European countries where sheep are actively shepherded, fenced and/or protected by dogs (Linnell & Cretois, 2018). In addition, losses of semi-domesticated reindeer to depredation by large carnivores are very high and difficult to mitigate.

The lynx[1], wolverine[2] and brown bear[3] are classified as endangered (EN) on the Norwegian Red List (2021), while the wolf is critically endangered (CR)[4], according to the Norwegian Biodiversity Information Center. Lynxes can be hunted as a game species with quotas, while the other three species are not classified as game but can be culled for management purposes using licensed hunters or government teams, depending on circumstances.

1 https://artsdatabanken.no/Pages/180905/
2 https://artsdatabanken.no/Pages/182501/
3 https://artsdatabanken.no/Pages/180928/
4 https://artsdatabanken.no/taxon/Canis%20lupus/48025

The government has issued three parliamentary reports on large carnivores, St. meld. nr. 27 (1991–92)[5], St.meld. nr. 35 (1996–97)[6] and St.meld. nr. 15 (2003–2004)[7], and a parliamentary majority settlement (Rovviltforliket, 2010–2011)[8] which established policy on wolf zones, large carnivore regions, and population targets for different species. Anderson et al. (2003) provide an excellent overview of the history of large carnivore management in Norway, with a summary of challenges and conflicts associated with the modern situation. To this day, conflicts persist, particularly with regard to wolf management. Skogen et al. (2013) argue that the wolf conflict is not between people and wolves, but between people with differing attitudes toward wolves. The fate of large carnivores in Norway is politically determined. For many, an important principle is not to eradicate native animals; considering that there are over 5 million people, there should be room for a few hundred large carnivores. On the other hand, many people feel that large carnivores only cause problems and should not be tolerated where they live, keep livestock, or hunt.

There is a noticeable conflict between people's identities (Jacobsen & Linnell, 2016; Schroeder et al., 2022) which will have a bearing on their attitudes toward large carnivores. Someone with a vegan identity may prefer banning livestock husbandry and hunting and view large carnivores as symbols of wild, unfettered nature that humans should not control. Those opposing large carnivores may have a rural identity that opposes centralized government, fear for people's safety, and want a safe environment for outdoor recreation and livestock. The Norwegian Parliament has made compromises but has not solved the conflict due to entrenched values and interests. Linnell et al. (2005) are right when they say there is no magical formula or solution for large carnivore conservation—only more or less acceptable and often controversial compromises.

KEY PRINCIPLES FOR LARGE CARNIVORE MANAGEMENT

The Norwegian Environment Agency (Miljødirektoratet, 2021) states: "Large Carnivore management is an area where instructions from the Parliament and government are particularly detailed. This is because politicians have weighed strongly conflicting interests against each other." As a result, populations of large

5 https://www.stortinget.no/no/Saker-og-publikasjoner/Stortingsforhandlinger/Lesevisning/?p=1991-92&paid=3&wid=b&psid=DIVL1267

6 https://www.regjeringen.no/no/dokumenter/st-meld-nr-35_1996-97/id191150/

7 https://www.regjeringen.no/no/dokumenter/stmeld-nr-15-2003-2004-/id403693/

8 https://www.stortinget.no/no/Saker-og-publikasjoner/Publikasjoner/Representantforslag/2010-2011/dok8-201011-163/?lvl=0

carnivores, which many view as symbols of unfettered nature and wilderness, are strictly managed with very detailed and restrictive goals for annual reproduction.

In Norway, the primary principle of large carnivore management is geographical differentiation. This means that in some areas, large carnivore populations are prioritized, with higher thresholds for culling and where preventive measures to protect livestock are emphasized. Outside these areas, livestock grazing on the open range is prioritized and large carnivores are actively removed. Management areas for lynxes, wolverines and bears are defined by the Regional Carnivore Committees in their carnivore management plans. The Norwegian Parliament has established a management zone for wolves.

Management of each species is based on specific population targets, monitoring regimes, measures to prevent and mitigate conflicts, hunting and culling as a regulating tool, and economic compensation for depredation losses. The Parliament has specified goals for populations based on annual reproductions: 65 for lynxes, 39 for wolverines, 13 for bears and four to six reproductive packs of wolves; three of these reproductive wolf territories must be wholly within Norway, and transboundary reproductive packs are counted by a factor of 0.5 (Ministry of the Environment 2003–2004, 2011, Parliamentary Report No. 100 (2008–2009)). The country is divided into eight carnivore regions with set goals for the number of reproductions in each of these for each species.

Here is an overview of the large carnivore management system taken from the official website of the Norwegian Environment Agency[9]. Within each region, Regional Carnivore Committees are responsible for maintaining carnivore populations at levels set by the Norwegian Parliament. These committees are appointed by the Ministry of Climate and Environment and the Sami Parliament.

These Regional Carnivore Committees create management plans for carnivores within their region, designating management areas. They are part of the environmental administration and operate under the Ministry of Climate and Environment. The County Governor serves as an advisor to the Carnivore Committees and acts as their secretariat. The County Governor is also responsible for handling individual applications related to preventive and conflict-reducing measures, compensation for losses of livestock and semi-domesticated reindeer, depredation culling, and applications for placement of live traps for wolverines and lynxes. Additionally, they manage the administrative aspects of carnivore hunting and culling within the county. The Environment Agency is responsible for large carnivore management at the national level. This includes administration relative to the Nature Diversity Act and the Wildlife Act, funding research projects, and

9 https://www.miljodirektoratet.no/ansvarsomrader/arter-naturtyper/vilt/rovvilt/rovviltforvaltning/

disseminating knowledge and information. It also serves as the appeals body for administrative decisions made by the County Governor. It provides expert advice and is subordinate to the Ministry of Climate and Environment. Municipalities are responsible for trained hunter teams that conduct the culling of animals that kill livestock. The Ministry of Climate and Environment is the overarching authority for large carnivore management and handles appeals regarding compliance with the Nature Diversity Act and the Bern Convention, which can be ultimately decided by the courts.

An overview of regional population goals for large carnivores in Norway is provided in Table 15.1. When the population of a carnivore species is at or above the target level, the Regional Carnivore Committee has management authority according to the carnivore regulations (marked in green). If the population is below the target level, the Environment Agency has management responsibility.

Table 15.1: Regional population goals for the four large carnivore species in Norway. The areas marked in green are species and regions where the Regional Carnivore Committee has authority.

Region (R)	**Lynx**	**Wolverine**	**Bear**	**Wolf**
R1 West Norway	–	–	–	–
R2 South Norway	12	–	–	–
R3 Oppland	5	4	–	–
R4 Oslo/Akershus/Østfold	6	–	–	4–6 (3)*
R5 Hedmark	10	5	3	–
R6 Central Norway	12	10	3**	–
R7 Nordland	10	10	1**	–
R8 Troms/Finnmark	10	10	6**	–
National Goals	65	39	13	4–6 (3)*

(*) Regions 4 and 5 have a shared population target for wolves, aiming for four to six annual litters, with three being fully Norwegian.
(**) The 2011 Large Carnivore Agreement states that bear management should be delegated to the regional carnivore committees when the national population reaches 10 annual litters or more. This applies even if the nationally set population target for the region is not met, as is the case for Regions 6, 7 and 8 in 2023 (marked in yellow). Source: Norwegian Environment Agency[10]

To manage carnivores toward precise population targets, management bodies rely on accurate population data. The Norwegian Nature Inspectorate (SNO) is supervised by the Environment Agency and conducts monitoring and documents depredations for compensation purposes. These data are compiled in the Rovdata

10 https://www.miljodirektoratet.no/ansvarsomrader/arter-naturtyper/vilt/rovvilt/rovviltforvaltning/

database[11], where updated population figures and extensive information on large carnivores and golden eagles are available. Avoiding data conflicts is essential for proper management of controversial species such as large carnivores. It is easier to mitigate conflict if everyone trusts and agrees upon the population numbers. That is why local people have been involved in counting large carnivores through snow tracking surveys, making reports to local large carnivore contacts or contributing with trail camera data through the project SCANDCAM [12] for documenting family groups of lynxes. Author Brainerd administered a system of line transects conducted by hunters and other local people for many years when he was working for the Norwegian Association of Hunters and Anglers. This helped to reduce data conflicts, which were very strong in the 1990s and early 2000s. Now this system has been discontinued, although people still conduct these surveys and record tracks of mammals and bird species and any family groups of lynxes encountered.

It is possible to apply for funding for measures that aim to prevent carnivore damage to livestock and domesticated reindeer. However, culling may also be necessary to prevent damage. Population survival should not be threatened by culling, and there should be no other alternatives to prevent damage. Hunting and culling may be necessary to keep large carnivore populations at target levels.

Carnivores can be culled under three regulations: 1) quota hunting, 2) licensed culling and 3) damage culling. Quota hunting is regular hunting with quotas set by authorities in different regions. Lynxes are hunted with quotas. Wolves, bears and wolverines are culled through licensed culling. The term "culling" is used because this is not ordinary hunting but a measure to remove non-game endangered species to meet set targets. Hunters participating in license hunts must register as licensed hunters in the hunter registry. Large carnivores can be killed through damage culling to prevent or stop ongoing depredations. Permission from landowners is required for quota hunting and licensed culling, but the Environment Agency can decide that culling occurs regardless of landowner rights. SNO can cull female wolverines with young in winter dens and bears in spring. Owners of livestock injured or killed by carnivores are entitled to compensation under specified conditions.

WOLF

Wolves are widespread across much of the Northern Hemisphere, are not globally threatened and likely arrived in Norway with wild reindeer before humans.

11 https://rovdata.no/Hjem/English.aspx

12 https://www.nina.no/Naturmangfold/Rovvilt/SCANDCAM

By 1966, wolves were considered functionally extinct on the Scandinavian Peninsula (Myrberget, 1978). With wolves no longer causing issues, environmental conservation emerged as a significant societal force, and wolves were initially protected in 1971 and permanently protected in 1973. In 1983, wolf breeding was documented again in Norway, at Finnskogen near the Swedish border (Wabakken et al., 2001), leading to increased populations and conflicts. These conflicts include (Liberg et al., 2010): 1) wolves kill sheep, preventing free-ranging sheep from grazing in wolf territories; 2) wolves kill moose, necessitating reduced moose quotas; 3) wolves kill dogs, making hunters wary of using free-ranging hunting dogs in wolf territories; and 4) people may fear wolves due to their perceived danger (Linnell et al., 2003). In 2017, the wolf conflict resulted in the largest public protest demonstration in Oslo since the EU debate in 1994 (Skancke, 2019).

Skogen et al. (2013) studied the wolf conflict in Norway and concluded that wolves are allowed to return because a majority of people today believe there should be some wolves in Norwegian nature. They found that earlier, the conflict was between humans and wolves; now, it is between humans with differing opinions and attitudes. Not everyone in rural areas opposes wolves, so there are many nuanced views. Most people are neutral with regard to wolves but prefer not to contradict neighbors and friends who strongly oppose wolves. Farmers, forest owners and hunters, who previously disagreed with regard to rights and land use, have united to form an alliance against wolves. The main opposition comes from ordinary men with little education and low income, who have settled in rural areas to enjoy outdoor activities like hunting and fishing. They view wolves as symbols of the modern society that has led to population decline in rural areas. Wolf supporters tend to be more highly educated, have higher incomes, and have more cultural interests. Research, management, the County Governor's office and the Environment Agency are filled with highly educated middle-class individuals. Environmental workers are accused of being particularly interested in preserving and protecting rare species and habitats. The main adversary for wolf opponents is not the wolf, but the highly educated middle class (Skogen et al., 2013).

Skogen et al. (2013) see wolves as a symbolic species in the conflict between an old utilitarian culture and a newer conservation culture. Underlying core values and identities clash, leading to high tension and difficulty in finding unifying solutions. Parties do not listen to each other, are far apart and struggle to understand each other's perspectives. This is likely due to conflicting identities, making compromise difficult (see Fukuyama, 2018), even though both sides deeply love nature and share many common interests.

The conflict level and the decision by the Norwegian Parliament to manage wolves at such a low level that the Norwegian Biodiversity Information Center categorizes them as critically endangered necessitate careful knowledge and management (Skogen et al., 2013; Krange & Skogen, 2018; Eldegard et al., 2021a). The Parliament has established boundaries for a management zone (wolf zone) where wolves are prioritized (Figure 15.1), while outside this zone, grazing animals are prioritized. Most farmers in the wolf zone have stopped raising sheep, although the number of sheep behind predator-proof fences has increased in recent years (Strand et al., 2018). Support for wolf protection increases with distance from wolf habitats (Karlsson & Sjöström, 2007), explaining why mayors inside the wolf zone oppose it while those outside support it. The Wolf Zone Committee (2012) proposed compensating affected municipalities with wolf territories by providing 8–10 million NOK annually, allowing the whole nation, which wants wolves concentrated in the wolf zone, to share the cost and potentially turn wolves into a resource. In 2017, the government allocated 20 million NOK to municipalities with wolf territories, but this was removed by the Center Party after the 2021 parliamentary election (see Chapter 3).

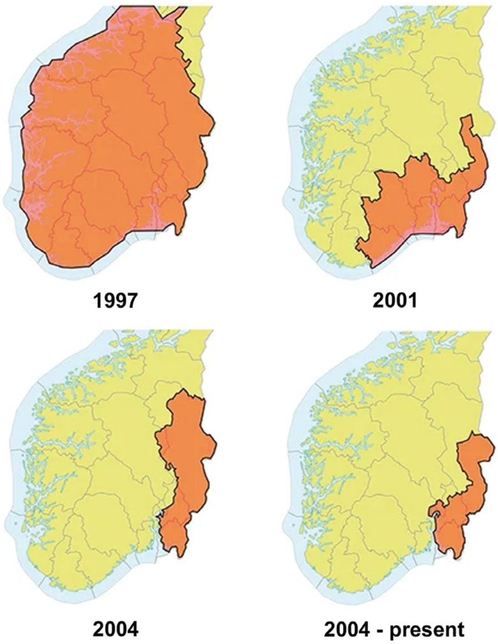

Figure 15.1: Parliamentary decisions have gradually reduced the size of the wolf management zone over time. (Source: Norwegian Ministry of Climate and Environment)[13].

13 https://www.regjeringen.no/no/dokumenter/meld.-st.-21-20152016/id2480008/

It is important to note that wolves reproduce quickly, with breeding pairs in a pack typically having four to six pups annually from the time they are reproductively mature at age two until they die at around age twelve. Population size is determined by prey availability and human predation. Reducing wolf populations that have developed freely has proven difficult with regular hunting (Mech, 2017). Norwegian hunters have learned to efficiently cull wolves in areas with plowed forest roads, using telecommunication equipment, flag lines and fresh tracking snow. Culling is more challenging in snow-poor, roadless, rugged forest terrain. To keep populations low, many animals must be culled annually, which has been difficult to accept, leading conservation organizations to repeatedly take the state to court to stop wolf hunts. Under the Nature Diversity Act (§ 18c), endangered species culling is permitted "to safeguard public health and safety or other public interests of significant importance." The focus is on whether population targets set by the Parliament are met, but the Bern Convention insists on a strict interpretation of these criteria. It can be challenging to demonstrate that issues such as moose, free-ranging hunting dogs, some sheep and minor fear in a small area of the country constitute public interests of significant importance for each specific wolf territory.

A unanimous ruling by the Borgarting Court of Appeal (Borgarting Lagmannsrett, 2022) established that wolves in the wolf zone should have special protection and not be culled if they behave as typical wolves do. Subsequently, Norway's Supreme Court (2023) determined that the focus should be on the population targets set by the Parliament, allowing wolves to be culled in the wolf zone when the population exceeds the target, provided the culling does not affect genetically important wolves and is unlikely to bring the population below the target.

The population on the Norwegian side of the border is so inbred and small that it is considered critically endangered according to the Norwegian Biodiversity Information Center. However, Norway's Supreme Court (2021) viewed the Norwegian population as part of the South Scandinavian population, which can survive with sufficient immigration from Finland.

The Scandinavian Wolf Research Project (SKANDULV)[14] has been conducting intensive research on wolves in Sweden and Norway since 1998. Author Brainerd was involved in this project at an early stage. The project has used GPS-telemetry, genetic methods and snow tracking to understand the biology, ecology and relationship to humans which has been fundamental to the proper management of this species in both countries.

14 https://www.slu.se/en/departments/ecology/research2/research/teman/wildlife-and-predators-/skandulv/

LYNX

The Norwegian Parliament set a goal of 65 lynx family groups (reproductions) annually in the country. These reproductions are allocated among seven of the eight carnivore regions. The Regional Carnivore Committee is tasked with developing a regional management plan indicating where lynxes should be allowed and where they should be removed. The committee can issue quotas when the number of reproductions exceeds the population target in the region. The quotas should be applied in accordance with the management plan for each region. The Scandinavian Lynx Project (SCANDLYNX)[15] has conducted research on this species in both countries since the mid-1990s and has provided valuable information essential to the proper management of this species.

Andrén et al. (2020) assessed how this arrangement has worked. They showed where family groups were confirmed in the winter of 2016–2017 in various regions in Norway and Sweden. In both countries, there has effectively been threshold harvesting, with an increasing portion of the population being culled as the population increases, and no harvest when the population is below the target. Andrén et al. (2020) have developed improved harvesting models based on threshold harvesting and good monitoring, reducing the risk of the lynx population deviating from target figures. The collaboration between hunters, researchers and Regional Carnivore Committees bodes well for the future of lynxes and lynx hunting. It requires constant close contact between the different stakeholders and the development of methods and models as new knowledge is acquired.

BROWN BEAR

In the mid-1800s, there were about 3,100 bears in Norway and 1,650 in Sweden. The policy in both countries was to eradicate bears, reaching its lowest point around 1930 when the population was nearly extinct in Norway, while about 130 bears remained in Sweden, where they were protected in 1913. The Norwegian population remained unprotected until 1973. The Swedish population was protected, and it grew, with hunting again being allowed in 1943 when the population was around 350 bears. It continued to grow under careful harvest management in Sweden. Since 1975 bears have migrated back into Norway (Swenson et al., 1995). Because the bear population occurred on both sides of the national border, the Scandinavian Bear Project[16] was initiated in 1984 and has produced over 350

15 https://www.nina.no/Naturmangfold/Rovvilt/SCANDLYNX/

16 https://www.brownbearproject.com/

peer-reviewed scientific articles. This research has provided important scientific insights into the biology and ecological relationships of this species that have been of great value to managers in both countries. We summarize the basics in the next paragraphs.

Bears hibernate in winter. Females reproduce first at four to six years old, and the cubs stay with their mother for two to three years before they mate again. Populations grow slowly and can be easily affected by hunting. Young females typically settle near their mother's home range. Where females are present, old, large males dominate. If the old male is culled, young male bears may kill the cubs of the old male to mate with the mother (e.g., Swenson et al., 1997). If the old male lives, young males may travel long distances into Norwegian sheep areas, where they can kill and maim sheep, searching for females. With the help of good bear dogs equipped with GPS transmitters that constantly show the position of the dog and thus the bear, a dense forest road network, and well-coordinated culling teams, these bears are usually culled.

Bears pose a threat to semi-domesticated reindeer farming and sheep grazing. A bear is large, strong and fast, and if wounded, with cubs or near a carcass, it can threaten or even kill people, causing some to fear bears. Bears kill some moose calves but are also a sought-after game species in other countries, leading many Norwegian hunters to travel to Sweden for bear hunting. The bear population is monitored by analyzing DNA from hair and scat, and updated information is available through Rovdata.

WOLVERINE

The wolverine is Norway's largest mustelid and has a relatively low reproductive capacity. They become sexually mature at one year, but both sexes typically reproduce at three to four years old. Globally, the IUCN considers wolverines as viable, but as mentioned in the introduction to this chapter the Norwegian Biodiversity Information Center classifies them as endangered in Norway. Wolverines are primarily scavengers, adapted to ecosystems with larger predators like wolves and bears. In Norway, they live in areas where these are mostly absent and also consume carcasses, semi-domesticated and wild reindeer, sheep, grouse, hares and lemmings.

Wolverines kill many sheep, especially lambs on pasture. High bounties were previously offered, and only a few wolverines survived far from humans in the mountains. After protection in Southern Norway in 1973 and the rest of the country in 1982, the population increased. There were initially two separate populations, one in Southern Norway and one part of a Northern Swedish population protected since 1968. These populations have since grown together with genetic exchange (Lansink et al., 2022).

The population target is 39 litters annually. Wolverine hunting is by licensed permit, and the Norwegian Nature Inspectorate (SNO) lethally removes females with cubs in dens in some areas. Nevertheless, there were 53 litters registered in 2021, and wolverines killed over 7,000 sheep on the open range (Miljødirektoratet, 2022b). Subsidy schemes exist for various measures to physically separate predators and grazing animals and for enhanced monitoring activities (Directorate for Nature Management, 2013b). Early gathering, bringing sheep home earlier than usual, is commonly used when wolverines are detected killing many sheep in an area. Wolverines could also have positive effects by killing wild reindeer weakened by hoof rot or other diseases, preventing disease spread (including CWD), as suggested by retired wildlife manager Tor Punsvik (2020).

Thirty years ago, wolverines were considered a mountain species, unlike in North America, where they were seen as a forest species. Author Brainerd was quite surprised to hear Norwegian colleagues adamantly state that the wolverine was a mountain species when he came to Norway in 1988. This was likely due to long persecution having exterminated them from lowland areas, where they are now returning (e.g., Moqanaki et al., 2023). Research has been conducted on wolverines in Norway and Sweden for many decades, and we now have a better picture of wolverine biology and ecological relationships that are important for management (May et al., 2008; Sæther et al., 2005). When left unmolested by humans, wolverines have shown that forest areas in Southeastern Norway provide good habitats. Over the past thirty years, the wolverine population has expanded. Earlier, the Norwegian wolverine population was classified into two subpopulations, one in the south and one in the north (Landa et al., 2000). Since then, the population has expanded in both directions and has merged in Norway and is continuous with the Swedish population (Moqanaki et al., 2023).

The wolf zone is nearly devoid of free-ranging sheep, allowing the wolverine population to grow, as studied by the GRENSEVILT[17] project. The primary food sources for radio-collared wolverines are hunting remains and carcasses, which rarely kill moose calves or small game (Aronsson et al., 2022). There have been no significant conflicts between people and wolverines in the wolf zone, even though the number of reproductions (18) is significantly above the management goal (five). Hunters would like to conduct sustainable wolverine hunting in the wolf zone, rather than having it completely protected. Wolverines are protected in Sweden, and in Norway, their numbers are kept in check through licensed permit

17 https://grensevilt.weebly.com/

hunting and actions by the Norwegian Nature Inspectorate (SNO) in reindeer and sheep grazing districts. It remains to be seen if wolverines can once again become a quota-hunted species in Norwegian areas without free-ranging sheep.

BIRDS OF PREY

In King Magnus Lagabøte's Land Laws (1274), birds of prey were considered resources belonging to landowners, and trained falcons were royal gifts. Folkestad (2018) mentions various uses for eagle body parts during Danish rule. The law of 1845 aimed to eradicate golden eagles, white-tailed eagles, goshawks and eagle owls, with no regulations for other birds of prey and owls. Hagen (1952) showed that most small birds of prey and owls primarily ate voles, which the legislators had noted. The 1951 hunting law protected all owls year-round, except eagle owls and snowy owls. Golden eagles, white-tailed eagles, goshawks, sparrow hawks (*Accipiter nisus*) and eagle owls could be hunted year-round, while other birds of prey could be hunted from August 21 to the end of February. Meanwhile, environmental toxins accumulate in birds of prey, leading to population declines. Golden eagles and white-tailed eagles were protected in 1968, and the rest of the birds of prey and owls were protected in 1971. Subsequently many were toxins banned, allowing birds of prey to recover. Folkestad (2018) reviews Norwegian golden eagle studies, noting that the breeding population has not increased much since it was protected. This suggests that hunting before protection did not significantly impact the breeding population, though the floating population of non-territorial eagles may have been smaller, allowing younger eagles to occupy territories when older birds were culled. The main difference between hunted and protected populations might be the average age of breeding birds and the size of the floating population.

Norway hosts 700–1,000 pairs of golden eagles (Gjershaug, n.d.). Golden eagles usually lay two eggs, but rarely more than one chick survives. As a thought experiment, if each pair lays two eggs annually, then 1,400–2,000 golden eagles, at the egg stage or older, must die each year to keep the population stable. Nonetheless, conservation organizations protested when the Ministry of Climate and Environment (2017) proposed a pilot project to ease the damage culling of individual golden eagles. The Norwegian Ornithological Society wrote: "It would be a significant setback for knowledge-based nature management if the 50th anniversary of eagle protection in Norway were marked by reduced protection of the golden eagle" (Folkestad, 2018, p. 10). A pattern emerges: when a species is endangered and protected, the attitude is that protection is crucial. When protection works and the population becomes viable again, the attitude remains that protection is crucial, regardless of the impact of culling on the population, people, livestock or other species. It seems unlikely that removing dozens of golden eagles in problem areas would significantly affect the breeding golden eagle population in Norway.

Shimmings and Øien (2015) estimated the white-tailed eagle population was between 5,600 and 8,400 individuals and increasing and had expanded into new areas in Norway (Folkestad, 2018). It is listed as a species of least concern by the Norwegian Biodiversity Information Center[18]. Media occasionally report that white-tailed eagles and golden eagles kill reindeer calves and lambs. Few sheep farmers and reindeer herders are affected, and there is broad agreement that birds of prey should be protected, with the state covering losses incurred by grazing users. There are concerns that the abundant white-tailed eagle is negatively impacting the red-listed kittiwake population in Northern Norway (Anker-Nilssen et al., 2023).

The golden eagle is listed as a species of least concern[19], but is fully protected. Ordinary hunting or licensed culling of golden eagles is not permitted, although the County Governor can grant permission for culling depredating golden eagles. The carnivore regulations require that the individual causing the damage must be identified before culling is initiated.

Between 2007 and 2021, nearly 1,000 to over 2,000 sheep and lambs were annually compensated as killed by golden eagles. It was confirmed that golden eagles killed over 500 semi-domesticated reindeer, with the state compensating over 8,000 reindeer taken by golden eagles in the 2020/2021 reindeer husbandry year (Miljødirektoratet, 2022c). The condition of calves seems to significantly influence whether they are taken (Tveraa et al., 2014). Regulations for carnivore management allow for the damage culling of golden eagles. A quick review in 2022 of the last 100 damage culling applications showed seven approvals and 93 rejections. The viable golden eagle population remains strongly protected.

MESOCARNIVORES

Hunting is permitted for red foxes, martens, stoats, badgers and the non-native American minks (Miljødirektoratet, 2022a). These species are of interest both as 1) furbearers and 2) predators of small game and other species that are vulnerable to their predation. Here, we focus on small predators as furbearers. All these species have very fine pelts, which were extremely valuable before synthetic materials became prevalent. Remains of fox and marten pelts have been found at settlements from the Stone Age, Bronze Age, and Middle Ages (Baxter & Hamilton-Dyer, 2003; Richter, 2005; Fairnell & Barrett, 2007). Etkind (2011) claimed that the

18 https://lister.artsdatabanken.no/rodlisteforarter/2021/7196
19 https://artsdatabanken.no/taxon/Aquila%20chrysaetos/3859

entire Russian empire was founded on the fur trade, with fur constituting a third of the Russian state's income in the 1600s (Vladimir, 2018). In the Middle Ages, pine marten fur served as currency in Croatia, and when this trade ceased, likely due to the depletion of martens, its image persisted on silver coins. In modern times, Croatia's currency was called the "kuna" (marten) from 1994 until 2023 when it was replaced by the Euro[20].

In Finland, pine martens and stoats were protected from April to November by the oldest laws, but in 1647 the pine marten was reclassified as a pest, and summer protection was removed (Mykra et al., 2005). In Sweden, pine martens experienced two periods of near extinction due to overexploitation, in the 1500s–1600s and again in the early 20th century (Helldin, 2000).

Before the 1845 law on eradicating predators and protecting other wildlife was passed in Norway, there was debate about whether the red fox was a pest or a useful animal. It was concluded to be useful due to its valuable fur (Richardsen, 2012). The high value led to the eradication of the slower, more K-selected marten and protection over large parts of the country, while the fast, r-selected red fox survived, though likely with reduced populations. The sarcoptic mange pandemic in the 1980s dramatically reduced the red fox population, but they subsequently recovered, as we have mentioned in an earlier chapter. The pine marten received complete protection in Norway in 1930[21] and became huntable again throughout the country in 1971. Fur value declined in the 1970s, mange reduced the tradition of fox hunting, and today marten, red fox, stoat and badger populations are likely limited by food availability rather than top-down pressure. American mink are an invasive species but are valued for their fur and as a recreational species for trappers.

Abundant populations offer excellent hunting opportunities without significant risk of reducing numbers. Reducing these populations would benefit many wildlife species. Wildlife managers can facilitate hunting or trapping of foxes, badgers, martens, minks and stoats. For example, Statskog provides access to hunting small predators on all state land (except state commons) for 100 NOK annually (iNatur, 2022). Managers can also organize bait stations and hides and listen to the wishes of potential predator hunters. See more regarding small mammalian predators in chapters 13 and 16.

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20 https://nc.cnb.cz/pub/en/from-the-world-of-the-money/The-pine-marten-and-the-Croatian-currency/

21 It is notable that when the pine marten was protected by law in 1930, the brown bear was already functionally extinct in Norway (Swenson et al., 1995) but would not receive full legal protection until 1973.

AUTHORS' REFLECTIONS

Hunters, landowners and local communities are the most inconvenienced by wolves where they occur in small parts of Norway. Lynxes take some roe deer, bears take some moose calves, but both species can be prized as game species by Norwegian hunters, although they must travel to Sweden to hunt bears as the population in Norway is very small and the species is not classified as a game species in Norway. A majority of Norwegians want wolverines (57%) and lynxes (68%) in the country and near where they live (Krange et al., 2017). Hunters or the general public have few issues with wolverines, and people generally enjoy seeing their tracks or animals in the wild. Livestock industries face challenges with all large carnivores, and Swedish farmers have negative attitudes toward all large predators even though losses are substantially less than in Norway (Larsson et al., 2022), although reindeer herders in both countries experience high levels of depredation (Pape et al., 2012). In Norway, there are fewer carnivores, yet our small populations cause the loss of 6% of sheep that graze without shepherding on the open range. In Sweden, there are far more sheep in areas with large carnivores than in Norway, but since these are kept in fenced pastures, losses to predators are extremely low compared to Norway (0.2%; Gervasi et al., 2021). Local production of mutton and reindeer meat utilizing wild forage depends on the near eradication of native Norwegian species.

Effective measures like reintroducing flock-forming sheep breeds with shepherding, as practiced 150 years ago, or grazing behind predator-proof fences represent a challenging transition that may not be socially or economically sustainable in Norway because of prohibitive costs. Continuing Sami reindeer herding and culture will likely depend on modern tools and the near absence of large carnivores. It is thought-provoking when one considers the amount of resources used to kill endangered predators to protect sheep, while obtaining permission to cull a few viable golden eagles in order to protect reindeer calves is very difficult. Are Sami reindeer less valuable than Norwegian sheep, or are viable, protected raptor populations more valued in our minds than endangered carnivores that are culled?

Whether or not there are a few wolf packs in Norway makes little difference to the genetic diversity or survival of wolves globally, but it matters greatly to many Norwegians. It matters so much that the Parliament has set detailed population goals that predator conservationists believe do not align with the Nature Diversity Act and ratified international conventions. In the USA, many environmental cases are decided in court, and Norway seems to be following suit.

Small predators like red foxes, pine martens and stoats have luxurious pelts. Fur trapping is an important first step for many young Norwegian hunters, as they are relatively easy to catch, and since it is possible for youths between 14 and 16 years old to legally trap and hunt small game under adult guidance before they can do so independently at age 16. We know that Norwegian trappers value marten trapping as a form of recreation and also consider it an important game management activity (Næstad, 2022; Jensen et al., 1998). Fur hunting and trapping are enjoyable pastimes, but it is essential to use humane traps for instant kills. Unfortunately, many people today discard the pelts they catch. Training in skinning and preparing wildlife pelts is crucial.

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16. Wildlife as an economic resource in Norway

In Chapter 5, we saw that wildlife management is a major industry in Southern Africa and Scotland. The question is whether a similar wildlife industry could be developed in Norway. This chapter first discusses the transfer of game management from the Ministry of Climate and Environment (KLD) to the Ministry of Agriculture and Food (LMD) and its possible implications. In Scotland, the wildlife industry is based on resources like red deer and red grouse, with an emphasis on maintaining dense populations. In Norway, efforts like those by Sætre Bruk in Hurum and Ytterøy Outfield Association[1] facilitate good roe deer management and hunting. However, we focus only on measures to increase populations of moose, red deer and forest grouse. Finally, we offer reflections on the future of the wildlife industry in Norway.

GAME MANAGEMENT TRANSFERRED TO THE MINISTRY OF AGRICULTURE AND FOOD

In 2018, the Solberg government moved the management of game species to the LMD, a change welcomed by the Norwegian Farmers' Association (Bondelaget; Ødegård, 2018). In 2023, the minority coalition government led by the Worker's Party and the Agrarian Center Party followed suit by transferring wildlife positions from the Environment Agency in Trondheim to the Agriculture Directorate in Steinkjer (Landbruksdirektoratet, 2023). Some stakeholders fear that wildlife will become a commodity (Risberg, n.d.). The Wildlife Act states that "production should be harvested to benefit outdoor recreation and agricultural industry," and the 2009 Cervid Strategy set goals for hunting, experiential travel, and niche industries to be recognized as an important component of the agricultural sector by 2015, and facilitating increased local value creation for hunting rights holders and other industry actors associated with hunting, tourism and meat production. LMD has established an Action Plan for business development based on harvestable

1 https://yul.no/

wildlife resources (Landbruks- og matdepartementet, 2019), followed by a study on the Use of Game Meat in Hotel Restaurant Catering (HoReCa; Opinion, n.d.). Andersen and Aas (2020) wrote the report "Hunting as an Economic Path," and the Norwegian Red Deer Center (2021) published from the preliminary project "More Game Meat". There is a clear desire to create greater economic value for game resources.

In their evaluation of the Cervid Strategy, Pedersen et al. (2021c) discuss the extent to which it is the public's role to develop wildlife industries for property and hunting rights holders. They conclude that it is a public role to remove barriers, inform and facilitate such development. Concrete proposals include measures for better organization of landowners with small properties to facilitate business development and the development of infrastructure and regulations for meat sales. The evaluation shows that hunting has yet to be recognized as an important agricultural industry.

Norwegian agriculture is governed by national agricultural policy. Norwegian farmers and landowners are independent business operators who adapt to agricultural policies and invest in profitable forms of production based on the qualities of their property and their qualifications (Løkeland-Stai & Lie, 2019). What is profitable is largely a political question. It can be challenging for a wildlife industry without subsidies to compete with subsidized industries. To achieve business development goals, it may have been wise to place the management of game species under the Ministry of Agriculture and Food, which can view wildlife in a holistic agricultural context. Most business development measures will be of an organizational, economic and logistical nature, which advisory apparatus and agricultural organizations have extensive experience with.

MEASURES TO INCREASE CARRYING CAPACITY FOR MOOSE

Moose need forage year-round. A review of relevant literature on moose nutrition indicates that summer forage availability and quality determine fall weight, and winter nutritional condition determines the number of calves that are produced in spring (Milner et al., 2013b). Females need to reach a certain weight to mate, depending on the location. If females have ample food through winter, more calves will be produced and survive until fall. If food is insufficient, there may be abortions, neonatal mortality and reduced summer survival (Milner et al., 2013a). Females with calves use much energy derived from summer forage for milk production. Hot, dry summers, especially early summer, can be so demanding that females with twins do not reach the weight needed for mating in fall. Swenson et al. (2007) found that females that lost calves to bear predation were able to gain weight during summer and had a higher probability of producing twins the following spring.

The carrying capacity for moose in an area is generally determined less by the characteristics of the moose population and more by how foresters perceive forest damage. In Finland, forestry is such an important industry that damage is not accepted; in Sweden, large forestry companies view moose more as a liability rather than a resource because of the damage they cause to tree production. In Norway, foresters value moose higher and allow denser populations, resulting in more browsing damage. Some forest landowners earn more from leasing rights for moose hunting than from wood production. In Norway, we harvest up to twice as much moose per unit area than in Finland and Sweden (Norway <0.01–2.5/km^2, Finland 0.05–0.45/km^2, Sweden 0.09–0.45/km^2 (Jensen et al., 2020).

Forest landowners who experience significant browsing damage and only moderate hunting income may have a more negative attitude toward high densities of moose. Solbraa (2008) suggests that a young pine is damaged if more than 40% of the branches are browsed. Forestry organizations are structured as companies that rely on timber income and not on moose hunting, so they have as a goal to reduce moose populations. However, there could be alternative solutions. As early as 1992, the project Moose-forest-community ("Elg–skog–samfunn") proposed ways landowners could provide more food for moose through regular forestry practices (Sæther et al., 1992). Large-scale experiments have been conducted to provide moose with forage through regular forestry practices (Loosen et al., 2021a). Moose have also been fed with silage bales (Milner et al., 2012; Milner et al., 2014), which is currently illegal due to the discovery of CWD in moose and reindeer in Fennoscandia (Tranulis et al., 2021). Feeding sites can act as disease transmission points. Silage alone does not meet all the nutritional needs of moose, and moose require supplemental natural forage for balanced nutrition (Felton et al., 2017). Supplemental feeding can cause forest damage near sites (Mathisen et al., 2014). If moose are to be fed, a different feed mix needs to be developed. When browsing damage on young pines is within acceptable limits, supplemental feeding can be profitable (Figure 3.1; Milner et al., 2012), but it is not a viable option as long as CWD is an issue. Successfully feeding moose or implementing other measures to maintain dense populations requires significant effort from landowners in the management plan area for a population. The major challenge is that moose cross property and administrative boundaries, making it difficult to know where a moose benefiting from measures is harvested, complicating the distribution of feeding costs. Loosen et al. (2021a) specify the following forestry measures that can produce more moose forage: (1) retention of forage biomass in slash piles created during forest cutting to increase short-term food availability and (2) intensified soil scarification to increase long-term food availability by reducing browsing damage as stands regenerate. They caution, however, that intensive site preparation may promote nutrient loss and decrease long-term site productivity and negatively impact important understory forage species such as bilberry. More experimentation is needed to determine the value of these actions, as moose utilize artificially provided forage very differently—from not using it at all to consuming everything. More research is needed to identify supplemental food compositions that can satisfactorily divert moose from damaging pine trees. The biggest challenge is coordinating between landowners in the area used by a moose population. The Ministry of Agriculture and Food should explore regulations and measures to promote such landowner cooperation.

MANAGEMENT MEASURES FOR RED DEER

In the 2021–2022 hunting season, over 50,000 deer were harvested in Norway, more than ever before. Red deer are a significant resource that, with strategic management, could enhance employment opportunities and add economic value. The Norwegian Red Deer Center on Svanøy[2] in western Norway has long worked to improve red deer management and develop the industry. It organizes wildlife conferences and courses and provides valuable management knowledge on its website. Deer hunters can improve individual skills in hunting, slaughtering, butchering and meat processing. Better management of the red deer population requires collaboration, especially between landowners, as well as with hunters and municipalities. Together, they should develop municipal management goals, which can facilitate consistent harvest profiles and match grazing supply with demand. However, it is the landowners who decide whether to develop better or more red deer forage and how to distribute the costs and revenues from this.

Deer eat grass. One of the biggest challenges in deer management in many western areas is that a few farmers focus on agriculture. They lease land from others, cultivate it and harvest grass for silage. These active farmers view deer as pests that consume much of their crops. Landowners, who lease out the land to farmers, want plenty of red deer for hunting. The majority, both in terms of people and land, want more red deer, leaving this minority of farmers to bear significant crop losses. One solution is to fence in cropland, but this would also require a substantial reduction in the red deer population, and fencing is expensive.

A challenge for profitable management is that red deer can use very large areas across many properties in multiple municipalities (Rolandsen et al., 2018;

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2 https://www.hjortesenteret.no/

Zimmermann et al., 2014). It can be difficult for landowners to agree on administrative boundaries for population management areas. If one landowner controlled the entire habitat of a deer population, they might overlook grazing damage as long as the income exceeded the losses. It would be interesting to see calculations comparing the positive value of harvested red deer and hunting income, based on deer grazing on farmland, against the negative value of crop loss. If agricultural subsidies were removed, or if meat from red deer was subsidized similar to livestock production, it might become even more favorable to let red deer graze on cultivated land. Exploring the conditions under which it would be profitable to grow grass solely for deer to graze could be beneficial. This would require transfers from those who benefit from having many deer to those who produce grass or face other economic disadvantages. The placement of pure red deer grazing areas would also need to be assessed concerning traffic routes with regard to the potential for collisions. To implement measures to increase the carrying capacity for red deer, all involved parties across most of a population's range must collaborate to distribute income and costs. Experimental areas that can serve as examples and that can inform the development of regulations are needed.

MANAGEMENT MEASURES FOR GROUSE SPECIES

Quality grouse hunting, especially high harvests of ptarmigan, is in great demand. In Britain, red grouse hunting is a billion-dollar industry. Potential measures include 1) improving habitats for willow ptarmigan in the mountains or forest grouse in the woods and 2) influencing factors affecting chick production. Habitat improvements could be achieved through forestry practices, while production enhancements would involve manipulating the "one-armed bandit" (see Chapter 13, p. 247) for more frequent success. Not many factors in the one-armed bandit can be controlled. Managers can adjust hunting quotas to ensure a sufficient spring population, and predator reduction works in Scotland. However, there is little that can be done about the North Atlantic Oscillation (NAO), rodent populations, bilberry production, and post-hatching precipitation and temperatures.

Regarding vegetation and succession stages, Barth (1891) noted large willow ptarmigan areas where valuable coniferous forests once stood, suggesting society suffered losses from intensive logging practices, which would be considered reckless today. Large-scale birch forest logging near mountains could create more ptarmigan habitat, but economic feasibility is uncertain, nor has it been tested through controlled experiments. A guide on forestry practices to benefit forest grouse has been developed (Søgnen & Hårstad, 2009), and the Norwegian forest standard sets requirements for logging capercaillie leks and bog woodlands (PEFC Norway, 2022).

This standard is based on the best biological knowledge. However, how autumn densities of adults and chicks vary with vegetation types and logging practices is unknown. Forage is probably not limiting, and predation pressure likely holds grouse populations below carrying capacity (Jahren et al., 2016; Wegge et al., 2022).

Controlling red foxes, martens, stoats and crows is essential for maintaining very dense grouse populations in Britain. Birds of prey are protected there as they are here, but grouse estates resort to illegally killing them to produce enough grouse for driven hunts (Grant et al., 2012; Newton, 2021). There is a significant difference between British grouse densities for wealthy hunters and what satisfies Norwegian grouse hunters. It is uncertain if legal predator control in Norway's continuous mountains would effectively increase ptarmigan populations, or if increased ptarmigan populations would attract protected birds of prey to the area, potentially offsetting any positive effects.

The Lierne Hunting Project[3] was initiated to implement measures reducing small predator densities to increase the harvestable population of game birds in the municipality (Rød-Eriksen et al., 2020). Measures focused on three main areas: 1) organization and dissemination of results, including a website, appointment of contacts in various parts of the municipality, involvement of local hunters and trappers, training in trapping, skinning, and pelting and organizing fur sales; 2) motivation and facilitation for increased harvest, including a communal hunting license, trap loan arrangements, free-use bait stations, tracking arrangements and various awards for documented capture of small predators and crows; and 3) limiting available human-made food sources, including collecting moose hunting waste, freezing it in containers, and reusing it as bait with Food Safety Authority approval, collecting roadkill and working with the municipality to seal waste facilities.

The report shows strong positive support for the project. They note a downward trend in indices for red foxes and martens and an increase in grouse populations. However, causal relationships are difficult to establish, and changes may be entirely coincidental. Intensive red fox culling on the Varanger Peninsula to promote Arctic foxes has led to higher willow ptarmigan production (Henden et al., 2020), but the effort and cost were high per extra ptarmigan produced.

On a property in Østerdalen in Southeastern Norway, ptarmigan and forest grouse populations have been surveyed since 1995. Since 2000, special permits have allowed for year-round control of small predators and crows. The landowners and hunters here are pleased that the ptarmigan population there has been greater than in neighboring surveyed areas. It appears that the ptarmigan population is not as heavily impacted during years of poor recruitment, possibly due to reduced

3 https://jaktilierne.no/

predation and limited harvesting during such periods. The results appear to confirm that predator control may have a positive effect on grouse populations, but it has yet to be scientifically evaluated.

The goal of such measures is not necessarily to reduce predators but to reduce predation in order to increase game abundance. Finne et al. (2019) conducted an experiment where the researchers fed red foxes during the breeding season for capercaillie and black grouse, which subsequently improved their reproduction. Predator control projects like those in Lierne and Østerdalen should be evaluated with many radio-tagged birds over a long period, with a substantial budget and control areas. Until proper scientific experiments with replicates are conducted over large areas to evaluate the effects of predator control on small game abundance, game managers will continue to conduct such measures without any certainty of success. Disease and parasites occur in dense ptarmigan populations in Norway (Holmstad et al., 2005). However, this is not a common problem and can be mitigated by increasing harvests and reducing the killing of predators.

In addition to population management measures, revenue can be increased by enhancing the hunting experience with easy access to terrain, good accommodations and additional services like guiding, catering, dog rentals and processing of meat and antlers.

AUTHORS' REFLECTIONS

In order to produce more productive, higher-density populations of the small and big game requires voluntary cooperation between landowners and managers across the property and administrative boundaries. Those holding hunting rights cannot be forced to cooperate under current regulations. In Norway, hunting rights belong to landowners, who typically lease these rights to third parties. Management is not so much about increasing hunting fees but rather about creating more attractive conditions that hunters are willing to pay for, such as good accommodations, increased harvest opportunities catered to their interests (increased bags or trophies), as well as guiding and assistance in processing game meat. An extensive wildlife industry like in South Africa or Scotland may counteract the goals of the Cervid Strategy regarding recruitment and public acceptance. Alongside good access to public hunting on large publicly owned lands, a wildlife industry that aims to create added economic value should expand offerings to Norwegian hunters. The Ministry of Agriculture and Food has a role in facilitating regulations and arrangements in cooperation with landowner and hunter organizations.

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17. Summary and final subjective words

We have now reviewed and discussed the breadth of the field of wildlife management from a Norwegian perspective.

In Chapter 1 we presented the present context of wildlife management—that we live in the Anthropocene, the age of humans. Humans are a unique species capable of believing in shared ideas and values and cooperating toward common goals. The nature we once depended on has been tamed and transformed, leading to many benefits for many people. Globally, the human population has dramatically increased. Humans and our livestock constitute 95–99% of the biomass of land-dwelling mammals. Our activities lead to the extinction of other species, global warming and loss of habitats. Many people are therefore concerned with preserving nature and the little wildlife that remains. Wildlife management is a goal-setting, action and learning process aimed at influencing interactions between wildlife, habitat and humans to achieve objectives in consultation with interest groups, based on the best available knowledge and practices. Wildlife management requires knowledge not only about wildlife species and their habitats but also about human values, stakeholders, legislation and scientific methods.

In Chapter 2 we discussed the colonization of Norway after the ice melted after the last Ice Age. Various wildlife species and people migrated in various ways and at different times. When the ocean filled the land bridge between Denmark and Sweden, the Scandinavian Peninsula became partially isolated from southern wildlife species and their diseases. Wild boars that entered before the sea opened became extinct and have not returned on their own. It is challenging for southern species to migrate north of the Gulf of Bothnia, as some golden jackals have managed. A distinctive feature of Scandinavian nature is the strong cyclicity in small rodent populations that provides a highly variable prey supply for predators. Humans are now the apex predators, supplanting carnivores and birds of prey. Many wildlife species populations exist at our mercy, with distributions limited in large part by our actions. Human-caused climate change, agriculture, and urban migration, as well as habitat loss and fragmentation, are reshaping habitats and living conditions for wildlife. Big game populations grow as much as people allow, while the small game is mostly kept in check by small predators like the red fox which itself benefits from human presence. Nature is changing, and unexpected events can alter conditions for wildlife and management.

In Chapter 3 we explored how values, ethical systems and morals have evolved and influenced how people perceive wildlife on different value scales. Values, beliefs and cherished beliefs affect our attitudes. When many values, beliefs and cherished beliefs influence attitudes toward wildlife, protection and hunting, it is very difficult to easily change these. People rarely change their behavior because they understand something is right, but do so if they are presented with equally good alternatives or through regulatory changes. People follow norms, especially when such norms are shared by many and enforced by laws and regulations. People value wildlife both positively and negatively; previously, game useful for its fur or meat was highly regarded, and predators were generally viewed negatively. Today, we focus more on threatened and endangered species versus invasive species. Hunting is no longer regarded as necessary for food procurement, but it is a culturally based activity that many enjoy practicing in a sustainable manner. Animal welfare and ethical practices are central tenets in the conduct of modern hunting. Rewilding aims to make nature wild again. The term is used for activities ranging from active manipulation of wildlife populations and habitats to completely "hands off" approaches where nature is left to take its own course. Researchers and managers may have many underlying values and beliefs and must be diligent in clarifying their roles. The general public plays the most important role in wildlife management; how wildlife will be managed in the future depends on the policies determined by the authorities.

In Chapter 4 we examined how legislation on hunting rights, protection of wildlife populations and animal welfare have evolved over time. Laws and regulations are a product of historical conditions as well, and have been honed by modern power dynamics, attitudes and values. The current Norwegian Wildlife Act is subordinate to the Nature Diversity Act, which aligns with international conventions. Management goals have shifted from exterminating predators and preserving "useful" game to preserving all native species and natural processes. The Wildlife Act is specified with regulations that can be easily changed as needed and is currently under major revision. Some court rulings show how local community attitudes do not always align with national norms, laws and parliamentary decisions on priorities based on the will of the majority. For hunting to continue to be accepted in the Anthropocene, hunters must behave in accordance with current norms and legislation.

In Chapter 5 we compared features of wildlife legislation and management between some different countries. Wildlife can be either completely protected or huntable. Where it can be hunted, various groups may have hunting rights, such as private landowners or the public. Likewise, the right to access uncultivated land can also belong either to landowners or the public. Management responsibility can lie with authorities or landowners. Where authorities manage wildlife on behalf of the public regardless of private property boundaries—and have ample resources—population management is much easier. Where hunting rights are open to all, anyone who wishes can participate in hunting if they meet legal qualifications. When landowners own hunting rights, hunting can become highly exclusive for a few. Complete protection of valuable wildlife seems to have dubious effects in countries with high corruption and underdeveloped government oversight. Wildlife management on private lands by landowners, especially in Southern Africa, has contributed to the conservation of valuable wildlife species. In the USA, wildlife populations recovered from near extermination by making it a publicly owned resource and by banning market hunting. In contrast, game populations rebounded when landowners were given exclusive hunting rights and associated economic incentives. There is limited knowledge regarding relationships between management systems, economic revenue, access and ownership, public attitudes and how these factors influence wildlife populations.

In Chapter 6 we discussed the concept of habitat, the place where wildlife can survive and reproduce, which is characterized not only by plant species and successional stages but also by predation and disturbances. The best scenario for wildlife species is large and contiguous habitats where numerous populations can live and develop. It is often difficult to define boundaries, and one must cautiously decide what should be managed as a population. Fast-growing, r-selected species can increase and decrease rapidly, while slow-growing, K-selected species increase population size more gradually, although they can decline rapidly if they exceed carrying capacity or are overharvested. For fast-growing species like grouse, we can expect large fluctuations between years, whereas for K-selected species like bears, populations change less between years unless people suddenly kill many. A challenge is that wildlife species are adapted to the conditions under which they have evolved. Climate change and extreme weather can impact populations. Carrying capacity is a defined ecological concept, but in wildlife management, production capacity—what can be produced without negatively affecting production in the food web—can be a more useful term. Populations are kept in check by limiting factors. They can be controlled by predation and/or hunting pressure (top-down) or by food availability (bottom-up). Small game is often kept in check from the top down by predation, particularly by red foxes in Norway. Big game in Norway is primarily controlled by hunting (top-down) but often remains near production capacity.

In Chapter 7 we explored different methods of monitoring and surveillance relative to needs and costs. Monitoring is essential to know which species and populations need protection, whether invasive species are present, and as a basis for determining quotas. For small populations of threatened or endangered species, detailed information, such as the genetics of individual animals, may be necessary to ensure survival. For most species, collecting such detailed information is too expensive. The common practice is to use indices, such as harvest or observational data from hunters. Citizens, including hunters and other nature enthusiasts, play a significant role in collecting monitoring data, while data processing, evaluation and reporting require specialized knowledge. The Norwegian Biodiversity Center maintains a species database that provides an overview of Norwegian wildlife population trends and status. For certain cervid and small game populations, harvest and monitoring data inform management. There is rapid technological development for improved non-invasive methods for monitoring wildlife populations.

In Chapter 8 we addressed the challenges of managing wildlife populations under uncertainty regarding factors that influence them. We presented systems for determining goals and for classification and evaluation of species and population development. Wildlife has been managed through various approaches, but adaptive management has emerged as a systematic decision-making process that is particularly valuable when there is significant uncertainty about the best strategy for managing natural resource It is an organized, cyclical method that emphasizes learning through manipulation of wildlife, habitats and/or human activities including harvests.

In Chapter 9 we examined how we can conserve native species that are struggling. Indices can show that populations are declining, and it is easy to hypothesize reasons for their struggles, but it is often very challenging to determine if one of the hypotheses is correct. Often, there are multiple factors that may contribute to population declines over time. We discuss various hypotheses regarding the decline of the Arctic fox in Norway, subsequent measures taken to ensure its survival, and the likelihood that it will still disappear due to global warming. The Eurasian eagle owl was common in Norway but has now become rare. Many hypotheses have been proposed for its scarcity, with much pointing to insufficient prey to rear young, but an important measure is preventing electrocution on power lines. Efforts to protect the lesser white-fronted goose highlight the different approaches taken between Norway and Sweden, and how it is essential that conservation of migratory populations must be coordinated at the international level.

In Chapter 10 we focused on invasive species that can threaten native Norwegian species. The best strategy is to prevent invasive species from entering the country, as illustrated by the ongoing efforts concerning the raccoon dog. Once species like the American mink have established themselves, efforts should be concentrated on reducing them where such measures are the most effective and beneficial. Wild boars were previously present in Norway, likely eradicated by humans, but are considered an invasive species according to current definitions; however, in Sweden, they are considered to be native although they were reintroduced in modern times. American mink and raccoon dogs pose a particular threat to ground-nesting birds, while wild boars can damage agriculture and are a potential threat to pig farming as a possible vector for transmission of African swine fever.

In Chapter 11 we discussed wildlife population harvests, examined the threat posed by overexploitation and concluded that hunting, when properly managed, does not threaten any species. We presented different methods of regulating hunting harvests depending on the available knowledge of various species, with the least precise approach through setting hunting seasons and the most precise through scientific evaluation of data for setting annual quotas.

In Chapter 12 we covered the management of economically important cervid species. Landowners aim to manage deer populations according to goals laid out in management plans. Management of wild reindeer should align with national goals and be approved by regional reindeer boards appointed by the Environment Agency. Management plans for moose, red deer and roe deer must conform to goals set and approved by each municipality.

In Chapter 13 we discussed grouse management. Grouse population productivity and densities depend on many factors that vary out of sync, most of which cannot be influenced locally. Predation from small predators such as red foxes often keeps populations at low levels, but the effort required to reduce predation is often costly compared to the benefits. The most important measure is usually to prevent hunting from driving the population so low that the breeding population next year falls below the level desired by managers.

In Chapter 14 we discussed management of other selected game species. Goose hunting can be organized to keep populations at production capacity. For most other huntable small game species, the harvest is usually so low that it is highly unlikely to impact population development under normal circumstances. Nevertheless, more research and better monitoring would be desirable from the perspective of interested wildlife managers, particularly if there is concern that a species population could be overharvested. With a view to hunter recruitment, it could be beneficial to organize and facilitate the hunting of species that are not expensive to hunt.

In Chapter 15 we examined predator management. Conflicts surrounding predators involve people with differing identities, making compromise often difficult. The wolf conflict is particularly intense because although wolves are native to Norway, they kill hunting dogs, compete with hunters for game and threaten free-ranging sheep. Comprehensive management systems, laws and regulations have been developed to allow endangered large predator species to survive in limited numbers with regulated culling while ensuring the survival of livestock industries impacted by their depredations. Small predator populations can have a negative impact on small game populations but are generally regulated by food availability rather than by hunting or trapping. Intensive predator control programs may have an impact locally, but are more likely to succeed on isolated islands with limited immigration compared to mainland areas.

In Chapter 16 we discussed the transfer of huntable wildlife management from the Ministry of Climate and the Environment (KLD) to the Ministry of Agriculture and Food (LMD) with the aim of developing a wildlife industry in Norway. LMD seeks to remove barriers to the development of commercial wildlife products, but the biggest challenge is getting those with hunting rights to collaborate across property boundaries. There is potential to develop denser populations of certain species and provide excellent services around hunting in some areas, which could benefit Norwegian hunters. However, developing a wildlife industry similar to systems in South Africa or Scotland may be disadvantageous for Norwegian hunters and could tarnish the reputation of hunting.

POLITICS AND ACTIONS DETERMINE THE FUTURE OF WILDLIFE

Throughout these 16 chapters, we have seen the extensive body of knowledge required for proper wildlife management. The loss of habitats and wildlife species since humans began with agriculture, particularly in the Anthropocene, has been immense. Only 1% to 5% of land-dwelling mammals are wild. Those who can see or hunt wild animals are privileged. It is easy to create realistic, alarming images of the state of nature and wildlife. Most people today live in cities with little biodiversity and get their food from agriculture which has degraded biodiversity. Yet, many live happily far from wild nature. Iceland emerged from the ice, and the Arctic fox is the only truly native terrestrial mammal. Despite this, Icelanders seem content.

The fate of biodiversity, wildlife and nature is in our hands. Nature, as we authors envision, will only survive if humans desire it. We see the preservation of nature, restoration efforts and combating climate change as the most crucial actions humans can take. We are focused not only on pure preservation, but also on conservation through use. We consider ourselves part of nature when we use it sustainably. Outdoor activities like hunting create advocates for a healthy, natural environment. Wildlife management is a crucial activity moving forward, one that must continually improve with new knowledge and perspectives. However, the most important actions must occur on a global scale. Without reducing greenhouse gas emissions, pollution and habitat destruction, we face a grim future.

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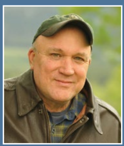
Appendix 1. Species hunted or culled in Norway

Family	English name	Norwegian name	*Latin name*
Phalacrocoracidae	European Shag	Toppskarv	*Gulosus aristotelis*
	Great Cormorant	Storskarv	*Phalacrocorax carbo*
Anatidae	Pink-footed Goose	Kortnebbgås	*Anser brachyrhynchus*
	Greylag Goose	Grågås	*Anser anser*
	European Wigeon	Brunnakke	*Mareca penelope*
	Eurasian Teal	Krikkand	*Anas crecca*
	Mallard	Stokkand	*Anas platyrhynchos*
	Tufted Duck	Toppand	*Aythya fuligula*
	Common Goldeneye	Kvinand	*Bucephala clangula*
	Red-breasted Merganser	Siland	*Mergus serrator*
	Common Merganser	Laksand	*Mergus merganser*
	Common Scoter	Svartand	*Melanitta nigra*
	Common Eider	Ærfugl	*Somateria mollissima*
Phasianidae	Hazel Grouse	Jerpe	*Tetrastes bonasia)*
	Black Grouse	Orrfugl	*Lyrurus tetrix*
	Capercaillie	Storfugl	*Tetrao urogallus*
	Willow Ptarmigan	Lirype	*Lagopus lagopus*
	Rock Ptarmigan	Fjellrype	*Lagopus mutus*
Charadriidae	Common Snipe	Enkeltbekkasin	*Gallinago gallinago*
	Woodcock	Rugde	*Scolopax rusticola*
Columbidae	Common Wood Pigeon	Ringdue	*Columba palumbus*
Turdidae	Fieldfare	Gråtrost	*Turdus pilaris*
	Eurasian jay	Nøtteskrike	*Garrulus glandarius*
	Magpie	Skjære	*Pica pica*
	Hooded Crow	Kråke	*Corvus cornix*
	Raven	Ravn	*Corvus corax*
Leporidae	Mountain Hare	Hare	*Lepus timidus*
Sciuridae	Red Squirrel	Ekorn	*Sciurus vulgaris*
Castoridae	Beaver	Bever	*Castor fiber*
Canidae	Red Fox	Rødrev	*Vulpes vulpes*
Mustelidae	Stoat	Røyskatt	*Mustela erminea*

Family	English name	Norwegian name	*Latin name*
	European Pine Marten	Mår	*Martes martes*
	European Badger	Grevling	*Meles meles*
Felidae	Eurasian Lynx	Gaupe (kvotejakt)	*Lynx lynx*
Cervidae	Red Deer	Hjort	*Cervus elaphus*
	Moose	Elg	*Alces alces*
	Roe Deer	Rådyr	*Capreolus capreolus*
	Wild reindeer	Villrein	*Rangifer tarandus*
Depredation culling			
Canidae	Wolf	Ulv	*Canis lupus*
Mustelidae	Wolverine	Jerv	*Gulo gulo*
Ursidae	Brown Bear	Bjørn	*Ursus arctos*
Invasive species			
Family	**English name**	**Norwegian name**	**Latin name**
Anatidae	Canada Goose	Kanadagås	*Branta canadensis*
	Bar-headed Goose	Stripegås	*Anser indicus*
	Muscovy Duck	Knoppand	*Cairina moschata*
	Mandarin Duck	Mandarinand	*Aix galericulata*
	Ruddy Duck	Stivhaleand	*Oxyura jamaicensis*
Phasianidae	Ring-necked Pheasant	Fasan	*Phasianus colchicus*
Leporidae	European Hare	Sørhare	*Lepus europaeus*
	European Rabbit	Viltlevende kanin	*Oryctolagus cuniculus*
Cricetidae	Muskrat	Bisam (bisamrotte)	*Ondatra zibethicus*
Canidae	Raccoon Dog	Mårhund	*Nyctereutes procyonoides*
Procyonidae	Raccoon	Vaskebjørn	*Procyon lotor*
Mustelidae	American mink	Villmink	*Neovison vison*
Suidae	Wild Boar	Villsvin	*Sus scrofa*
Cervidae	Fallow Deer	Dåhjort	*Dama dama*
Bovidae	Mouflon	Muflon	*Ovis gmelini*

Wildlife management in Norway previously focused on harvesting edible game species and exterminating predators. In the Anthropocene—the Age of Humans—people and livestock have completely taken over the planet (95–99% of mammal biomass) and have displaced wild animals (1–5% of biomass). Wildlife management now faces new challenges, including habitat loss and climate change. Wildlife managers use their knowledge to plan, conduct and evaluate measures to achieve management goals. Native species and habitats should be protected or conserved, while invasive species should be combatted.

A wildlife manager requires ecological knowledge regarding species and ecosystems, and all measures should be conducted within a legal framework. Laws and regulations vary between Norway and other countries based on culture, traditions and power structures. Much research focuses on solving nature conservation issues. Wildlife management is distinguished by its focus on conservation through sustainable use. To ensure the future of hunting, game species and their habitats must be sustainably managed in the long term. Hunting must be perceived by the public and authorities as being socially, economically and biologically sustainable.



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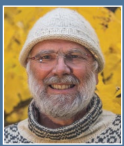

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