Oh, For Wildlife's Sake! Let's Be Honest About Conservation & Management

Chapter 1

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Abstract −Wildlife conservation and management are in a state of crisis. On the basis of nearly 50 yrs as a field wildlife biologist, researcher and manager, I identify issues that impact on wildlife. These relate to species-at-risk, habitat loss, human-wildlife conflicts including predator and "pest" control, pollution, animal welfare, invasive alien species, bad management caused by socio-political interests, and the North American Model for Wildlife Conservation. I propose solutions in a series of points to ponder to implement proper procedures, recognize and protect valuable habitats, preserve and ensure the perseverance of populations, and prevent or reduce pollution, pesticides and invasive species. Finally, I identify basic principles that should be considered when developing a model for wildlife conservation: 1) Wildlife is an integral component of people's environment; 2) The cost of conservation and management are borne by all citizens and funds are entirely dedicated to wildlife populations and habitats; 3) The maintenance of viable wildlife populations always takes precedence over their use by people; 4) Wildlife habitat conservation, restoration, and connectivity always takes precedence over landscape development and use by people; 5) Animal welfare concerns are properly addressed in all consumptive and non-consumptive wildlife use; 6) Invasion of alien species, and the source of these invasions, are immediately stopped; 7) Wildlife conservation is based on multi-disciplinary consultations; 8) Wildlife conservation and management are science-based; 9) Public education, school programs, and community initiatives are essential components of wildlife conservation and management programs; and 10) Funding needs to be consistent and apolitical from year to year. The future of wildlife ultimately depends on dedicated wildlife biologists with high professionalism and ethics, working together to implement effective science-based conservation and management programs.

Introduction

In the last 2 decades, the overall number of threatened vertebrates, invertebrates, vascular plants, and fungi and protists has nearly doubled (IUCN 2022), and large tracts of wilderness areas (particularly in Africa and South America) and protected land with relatively low human pressure have declined significantly (Watson *et al.* 2016; Jones *et al.* 2018). In Europe and the United Kingdom, approximately 18% of vertebrate species are threatened with extinction (IUCN 2022; National Biodiversity Network 2022). In the United States, 52% of species at risk declined from 1990 to 2010 (Evans *et al.* 2016). In Canada, the number of vertebrate species at risk (SAR; endangered, threatened and of special concern) has increased by 1.75-fold over the last 20 yrs (COSEWIC 2001, 2021). With an increase in human terrestrial footprint and in species extinction risk (Di Marco *et al.* 2018), and limited win–win scenarios to improve both natural resources and human well-being (McShane *et al.* 2011), wildlife is in trouble.

Despite many conservation and management models, concepts, and opinions (e.g., Akama *et al.* 1996; Gill 2004; Organ *et al.* 2012; Macdonald *et al.* 2012; Decker *et al.* 2016; Serfass *et al.* 2018; Sullivan *et al.* 2022; and many more), most mammalian megafauna face dramatic range contractions and population declines (Ripple *et al.* 2016); rare and common birds (Choudhury 2006; Inger *et al.* 2015), and amphibian and reptile species (Gibbons *et al.* 2000; Araújo *et al.* 2006), are in decline; and wildlife habitats are being lost and fragmented (Pardini *et al.* 2017; Kuipers *et al.* 2021). Whereas human activities deprive wild animals of their life requisites by destroying or impoverishing their surroundings and causing suffering of individuals (Paquet and Darimont 2010), wildlife programs and activities are plagued with ineffective standards and test procedures impacting significantly on animal welfare (Proulx *et al.* 2020), an overall lack of attention to animal welfare science (Dubois *et al.* 2017; Field *et al.* 2019), and ineffective, unselective and unethical predator control programs (Brook *et al.* 2015; Proulx and Rodtka 2015). Finally, as wildlife professionals aim to conserve endemic species, they must also deal with invasive species, which impact on the integrity of ecosystems and the survival of many species (Towns *et al.* 2012; Kliewer *et al.* 2022).

In this chapter, I present a series of issues and concerns that show how wildlife conservation and management are in a state of crisis. This review is not meant to be exhaustive in any one area. Although I provide examples from different countries, I largely base my review on my past experience of nearly 50 yrs as a field wildlife biologist, researcher and manager, and I pay particular attention to wildlife in Canada. Obviously, I lean heavily on my own research publications to make my points. I also review the prevalent North American Wildlife Conservation Model that has been largely adopted or slightly modified by wildlife agencies in Canada and the United States. Finally, I provide a series of *points to ponder* to address current issues and concerns, and improve upon wildlife conservation and management programs in the 21st century.

Definitions of wildlife conservation and management

For many, wildlife conservation and management are interchangeable concepts. However, not all wildlife management activities result in wildlife conservation. The dictionary definition of conservation is preservation from loss, injury, decay or waste; it is the protection of rivers, forest, and other natural resources (The Random House College Dictionary). In this paper, I consider that wildlife conservation is a practice used to ensure the persistence of wildlife species, populations and habitats. In contrast, wildlife management is a practice used to assess and integrate the needs of wildlife with the social, economic and political interests of people. Giles (1997) defined wildlife management as "faunal resource management", which is making decisions and taking actions to manipulate the structure, dynamics, and relations of wild faunal populations, faunal space, and human behaviour to achieve specific human objectives.

A Series of Issues

Species at risk

The number of species at risk (all taxa) has increased dramatically over the last 2 decades. Globally, the number of SAR increased from 11,167 species in 2002 to 41,459 in 2022, an increase of 371% over 20 yrs (Figure 1). In the USA, SAR numbers have increased by 32% from 2003 to 2021 (Knowles and Flather 2019), and in Canada, they nearly tripled from 2003 to 2020 (Environment and Climate Change Canada 2022) (Figure 1).

Of course, one must be careful when comparing the number of SAR estimated at global and country levels. There is a lack of coherence between ranking systems, and while some organizations may assess species and sub-species, others evaluate species only. Also, the parameters used to rank species may vary from one classification system to the other. As a result, the incoherence in the ranking of species and subspecies leads to confusion when comes the time to develop conservation policies and prioritize recovery programs (Proulx *et al.* 2016). For example, in British Columbia, Canada, COSEWIC and the B.C. Ministry of Environment classify the American badger (*Taxidea taxus jeffersonii*) as an "Endangered Species" that is facing imminent extirpation or extinction (B.C. Conservation Data Centre 2013). In the adjacent State of Washington, it is rated as a "Species of Greatest Conservation Need" but is still harvested; in Oregon, south of Washington State, the species has no status (Proulx *et al.* 2016). Although COSEWIC (2012) raised concerns about the conservation of this species, IUCN rated the American badger as a "Species of Least Concern", i.e., that is not threatened or endangered (IUCN 2013a; Reid and Helgen 2016).

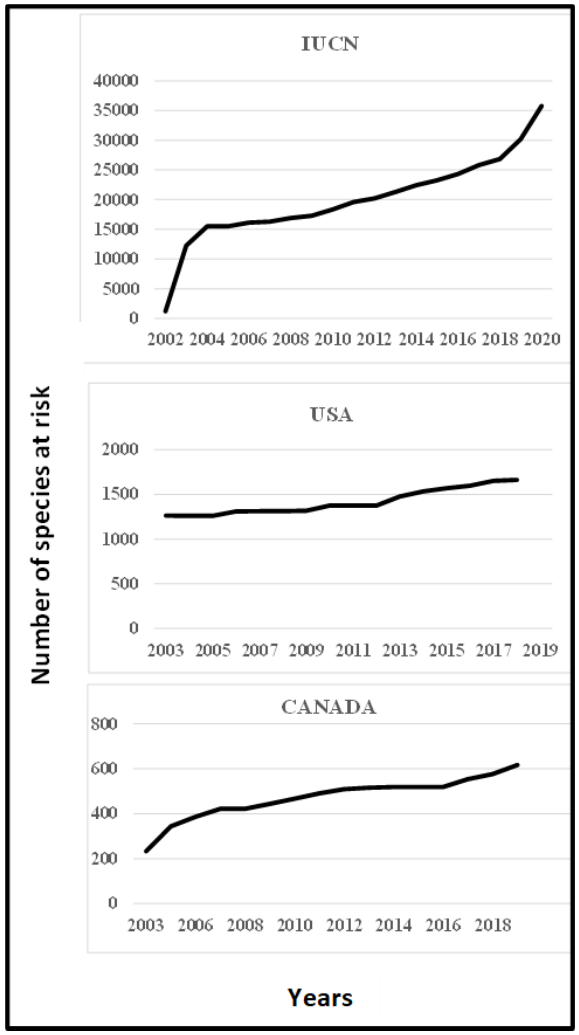

Figure 1. Number of species at risk (all taxa) in the world (IUCN 2022), in the United States (Knowles and Flather 2019), and in Canada (Environment and Climate Change Canada 2022).

COSEWIC (2022) pointed out that the increase in total number of wildlife species that they assessed does not provide evidence of a worsening endangered species crisis. Also, the total number of endangered, threatened and special concern wildlife species assessed by COSEWIC will continue to increase into the foreseeable future because COSEWIC is far from being finished assessing suspected at-risk wildlife species. Furthermore, when reviewing SAR reports published in Canada since the early 2000s, one notices that criteria, members of the COSEWIC, and scientific data have changed in quality and quantity over the years (Canadian Endangered Species Conservation Council 2001, 2006, 2011, 2015; Environment and Climate Change Canada 2022). Nevertheless, the increase in the number of SAR over the years is not simply the result of COSEWIC's data process. Factors associated with the Species at Risk Act (SARA; 2002) process do not contribute to the proper conservation of SAR.

Delayed process

The identification, protection and recovery of SAR is undeniably a difficult task to carry out in today's social, cultural, economic, and political contexts. In Canada, the Species at Risk Act (SARA 2002) is a long, convoluted and vague process where scientific evidence is confronted with a complex bureaucratic process and political review delays (Figure 2) involving 3 primary agencies: 1) Environment and Climate Change Canada, which is responsible for the general management of SAR; 2) Fisheries and Oceans Canada, which is responsible for aquatic SAR; and 3) Parks Canada, which is responsible for all SAR occurring in national parks and historic sites. Taxa are split among respective agencies for the development of recovery strategies. The process leading to the development of a recovery plan and the production of an action plan may easily exceed 8 yrs (Figure 2), a long time period which may mean extinction for a critically endangered species. Inaction and unnecessary delays kill SAR. In all accounts, this is not the fault of naturalists and wildlife professionals involved in the process – they all want to find a solution to a species-at-risk problem. Delays are largely a bureaucratic issue where people try to balance ecological concerns with socio-cultural and political interests.

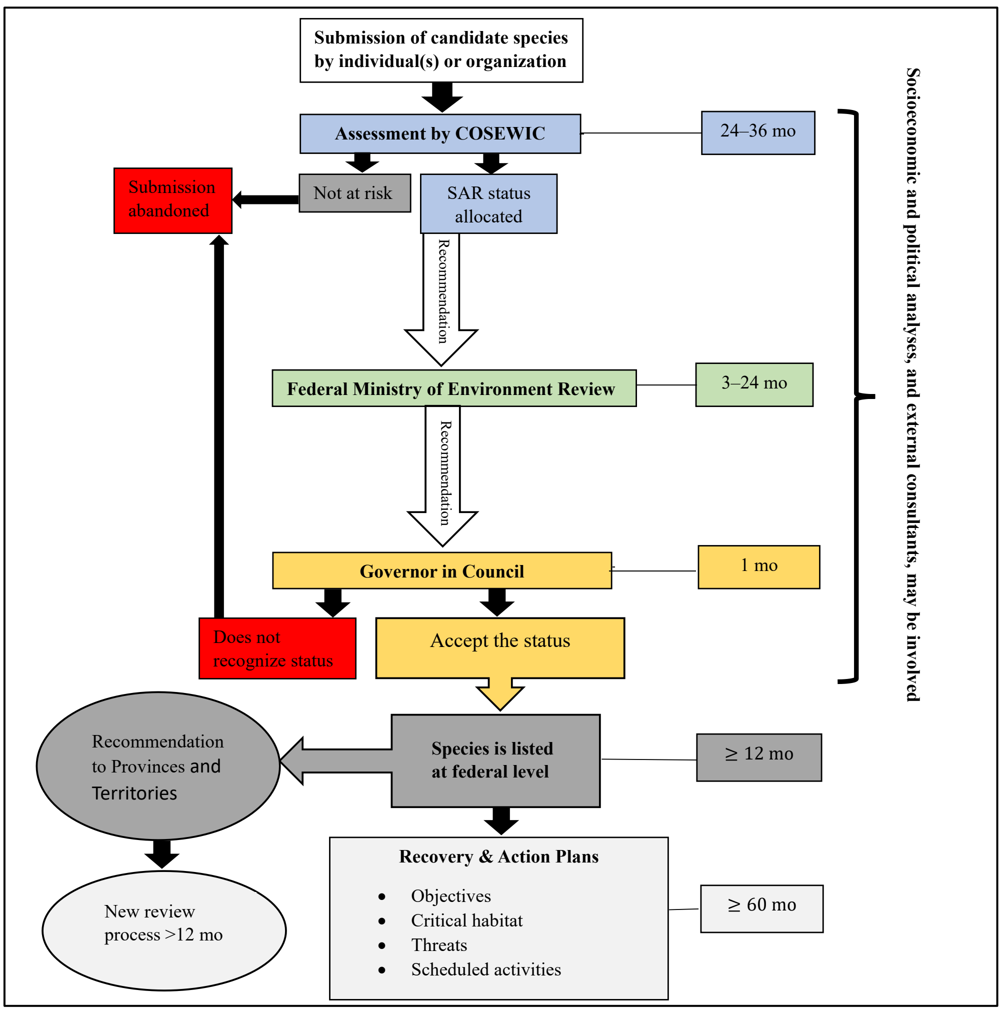

Figure 2. Schematic representation of the COSEWIC process.

A system weakened by socio-political assessments

Listing a species as being at risk must be based on scientific evidence. A significant change in the abundance and the distribution of a species usually raises the initial concern to assess the status of a species. However, even if COSEWIC considers a species is in peril, the Canadian government may not legally list a species on the basis of public consultations and internal economic assessments (Mooers *et al.* 2010). This means that a species may not receive the proper legal protection to persist in the future, or its status may be re-evaluated at a later date when the species may have reached a point of no return.

The SAR status has limited application

The status of SAR typically applies only to federally managed areas, which is approximately 4% of the Canadian landscape (Mooers *et al.* 2010). The responsibility for protecting wildlife species on lands managed by provinces and territories usually fall to the province or territory (Mooers *et al.* 2010). For example, whereas the boreal woodland caribou (*Rangifer tarandus caribou*) was listed as 'threatened' under the federal Species at Risk Act since June 2003, conservation measures at the provincial level in Alberta have been delayed and failed to address the critical factor responsible for the demise of the species, i.e., habitat loss and fragmentation (Wasser *et al.*2011; Proulx 2015; Proulx and Powell 2016; Proulx and Brook 2017). Environmental groups have unsuccessfully petitioned the Minister of Environment and Climate Change Canada to enforce critical habitat protection orders for caribou herds in Alberta (Ecojustice 2017), and this Minister did not produce an emergency order to provide protection for the species and its habitat on public and private provincial lands (Turcotte *et al.* 2021). However, this may change in the near future. Ross (2023) reported that the federal Environment Minister was prepared to recommend to cabinet that a protection order be placed in Ontario to protect caribou habitat. This was, reportedly, after the Ontario Environment Minister earmarked $29 million CAD over the next 4 yrs toward caribou habitat restoration, protection and conservation.

Similarly, although the American badger (*Taxidea taxus*) has been listed as a species of special concern at the federal level (COSEWIC 2012), largely because of human persecution (Proulx *et al.* 2016), the species is still being hunted in the Prairies (Fenson 2016; Proulx 2017a). Yet, unless the conservation of species with the status of special concern is properly implemented at provincial and territorial levels, these species will eventually be listed as threatened (Favaro *et al.* 2014).

Initiating a SAR recovery plan largely hinges on 1 definition

The implementation of a recovery program for a SAR requires that the species' critical habitat has been defined. According to the Species at Risk Act, section 2(1), "Critical Habitat means the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' Critical Habitat in the Recovery Strategy or in an Action Plan for the species". Intuitively, the historical presence of a species in specific areas obviously suggests that this species finds the resources necessary for its wellbeing, reproduction, and survival; the habitat that is currently used by a species likely corresponds to − or at least includes − the critical habitat requirements. However, the definition of critical habitat is apparently subject to biological interpretation on survival and recovery, and such interpretation could result in a delay in identifying the critical habitat of a species (Mooers *et al.* 2010). Using species persistence as the criterion to identify critical habitat requires information about the amount and quality of habitats, the relationship between habitat and population viability, the target population size or distribution needed for long-term population viability, and the amount and location of habitat needed to achieve the desired targets (Pulliam and Danielson 1991; Rosenfeld and Hatfield 2006). However, the characteristics of the critical habitat for a species could change among ecozones (e.g., Proulx 2017b; Figure 3) and require more than one designation of critical habitat. Overall, data limitation may be the main reason for an inadequate identification of critical habitat (Camaclang *et al.* 2014). Furthermore, to my knowledge, it has not been demonstrated that a legally acceptable definition of critical habitat would contribute significantly to the persistence of a species. The definition is as comprehensive as the criteria used by humans to determine what is significant for a species. Some significant aspects of the life history of a species may be overlooked due to our lack of data, and this alone may prevent us to develop an effective definition of critical habitat. Moers *et al.* (2010) reported that critical habitat had been identified for just 23 (5%) of 447 listed species.

In this case, a lack of definition means that listing a species as being at risk may not be followed by an action plan to ensure the long-term recovery of the species.

There are deficiencies in the SARA process and application (including the definition of critical habitat), variations in legislation among provinces and territories, and a reluctance of the federal government to implement SARA on non federally managed lands (Turcotte *et al.* 2021). These variations and irregularities impact significantly on the conservation and management of SAR in Canada.

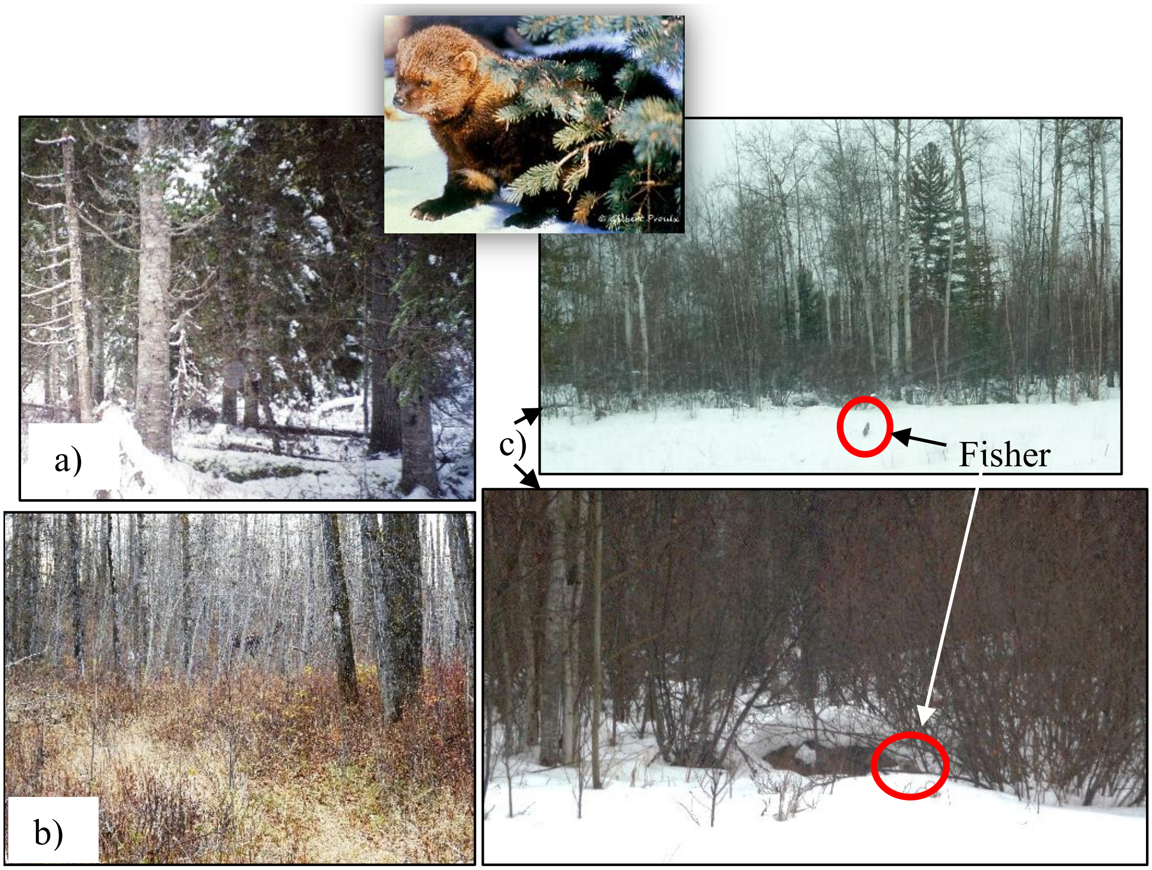

Figure 3. The critical winter habitat for fisher (*Pekania pennanti*) changes among ecozones: a) Montane Cordillera Ecozone of B.C. where fishers select late-successional mixed coniferous stands; b) Prairies Ecozone of central Alberta where fishers select deciduous forests with well-developed understories; and c) Boreal Plains Ecozone of Saskatchewan where fishers use mosaics of black spruce (*Picea mariana*) bogs, and coniferous, mixed, and deciduous forest stands (Proulx 2017b) (Photos: Gilbert Proulx©).

Habitat loss

Habitat loss is the leading threat to imperiled species globally (affecting 87% of species; Baillie *et al.* 2004), in the United States (89%; Wilcove *et al.* 1989), and in Canada (84%; Venter *et al.* 2006). Habitat loss is also the most common threat to terrestrial species not at risk (Schmiegelow and Mönkkönen 2002; Proulx *et al.* 2004, 2016). This can easily be surmised on the basis of tree cover loss over the years. From 2001 to 2021, there was a total of 437Mha of tree cover loss (~11% of total cover since 2000) globally (Global Forest Watch 2022a) (Figure 4). During this time period, the United States lost 44.3Mha of tree cover, equivalent to a 16% decrease in tree cover since 2000 (Global Forest Watch 2022b); and Canada lost 46.6Mha of tree cover, equivalent to a 11% decrease in tree cover since 2000 (Global Forest Watch 2022a) (Figure 4). Habitat loss to agricultural lands and urban areas has contributed substantially to the endangerment of many species around the world, Canada included (Coristine and Kerr 2011; Imre and

Derbowka 2011). Furthermore, it has been exacerbated by climate change, which impacts on the distributional limits of species ranges (Corisine and Kerr 2011).

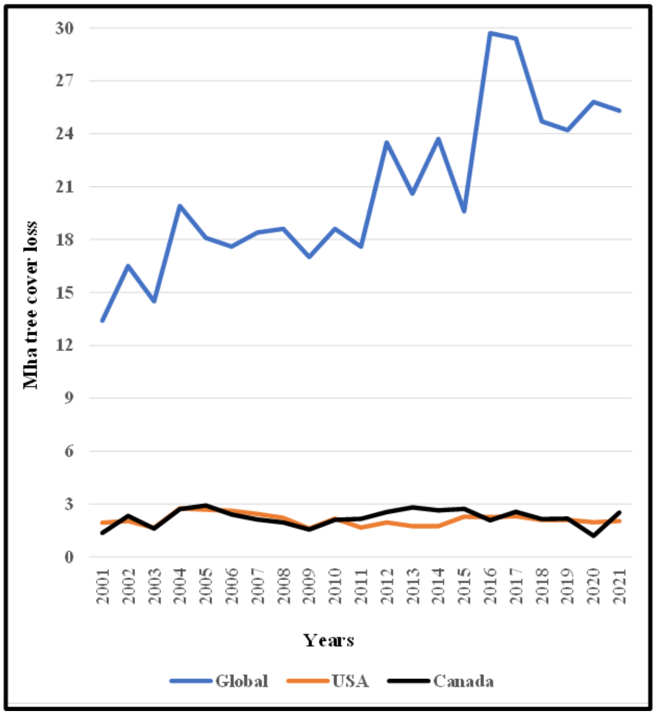

Figure 4. Total Ma of tree cover loss globally, in the United States, and in Canada (Global Forest Watch 2022a,b).

Vulnerable species

Habitat quantity and quality change through loss or fragmentation (i.e., the breaking apart of habitats; Fahrig 1997), both temporal and spatial, particularly affect rare species (Summerville and Crist 2001), habitat specialists (Carlson 2000; Proulx and Aubry 2017), and species with low dispersal rates (Virgós 2001; Coulon *et al.* 2004). Habitat specialists and specialist predators are impacted at lower levels of habitat loss than those experienced by habitat generalists (Dykstra 2004) and generalist predators (Swihart *et al.* 2001). Rare species disappear at lower levels of habitat loss than do generalist species (Gibbs 1998). Also, species with lower reproductive rates are more negatively affected by landscape-scale habitat loss than are species with higher reproductive rates (Quesnelle *et al.* 2014).

Safeguards

The Government of Canada added approximately 38 million ha to the protected areas system between 1989 and 2000. Thus, an estimated 6.84 % of Canadian ecosystems were protected by early 2000s compared to 2.95 % in 1989 (McNamee 2002; Dearden and Dempsey 2004). This is a significant increase. However, while most Canadian provinces and territories make some reference to biodiversity on their government webpages, few of them present biodiversity strategies for the creation and management of protected areas, and the protection of SAR and their habitats (Ray *et al.* 2021). There is a constant tug-of-war between business interests concerned about unnecessary regulatory barriers and those who would like to see strong environmental safeguards (Foran 2018, p. 42; Ray *et al.* 2021).

Climate change

Climate change could have positive effects on biodiversity. For instance, more clement temperatures and increased CO_2 are likely to be beneficial to many plants, resulting in an acceleration of biomass production

(Rustad *et al.* 2012). However, habitat loss and wildlife community alterations will generally be exacerbated by climate change (Pimm 2008). A reduction of snowy and cold environments due to warmer temperatures could have a significant impact on SAR, such as the wolverine (*Gulo gulo*) (Aubry *et al.* 2023). A change in temperatures, and in the frequency of floods and droughts, and resulting vegetation range shifts, will impact on food and water supplies, and ultimately on the abundance and distribution of animal species (Hannah *et al.* 2002). This is particularly true for amphibians which are particularly sensitive to changes in temperature and precipitations (Gibbs and Breisch 2001). Moreover, several studies reported detrimental effects of climate change on biological invasions (e.g., Peterson *et al.* 2008).

Canada is one of the top Green House Gas (GHG) emitters, (UN Environment Programme 2022). The Government of Canada is committed to protecting 25% of its land and 25% of its oceans by 2025, using nature-based solutions (e.g., by absorbing and storing greenhouse gases, regulating water levels, protecting shorelines) to fight climate change, and reaching net-zero greenhouse gas emissions by 2050 (Government of Canada 2023a). However, some provincial governments disagree with the objectives of the federal government, and prioritize economic returns over environmental concerns (Graney 2021; von Scheel 2022).

The Government of Canada intends to work in close collaboration and partnership with First Nations, Inuit and Métis to address climate change, and will be investing $460 million CAD over 5 yrs, to protect and expand 22 of Canada's national wildlife areas (Government of Canada 2021). The Government of Canada (2022a) also announced more funding to reduce GHG emissions and secure lands. These are positive actions. However, giving large amounts of money to various groups to recognize protected areas does not guarantee that habitat loss caused by climate change will be kept under control. Specific projects involving habitat acquisition, protection and restoration plans, followed up by wildlife inventories, continuous monitoring, and adaptive management actions to assess and mitigate climate change and habitat loss, need to be identified. The threat of climate change will significantly increase in the next decade, and it should be a priority to monitor all threats, but particularly climate change, on wildlife species in Canada (Woo-Durand *et al.* 2020).

Human-wildlife conflicts

Predator control

The majority of terrestrial large carnivores have undergone substantial range contractions, and are endangered, at the global level (Wolf and Ripple 2017), in the United States (e.g., Ripple and Beschta 2018; Ripple *et al.* 2019), and in Canada (Laliberte and Ripple 2004). Large carnivores suffer from habitat loss (see precedent section), prey depletion (Wolf and Ripple 2016), but largely from lethal persecution (Kellert *et al.* 1996).

Of all the large carnivore species, the grey wolf (*Canis lupus*; Figure 5) has been the most persecuted; large populations are now found only in northern Canada and Alaska (Musiani and Paquet 2004). The extirpation of wolves occurred, and continues to happen, in regions where livestock production (Hayes and Gunson 1995; Mech 1995) and big game hunting (Gasaway *et al.* 1992; Musiani and Paquet 2004) is valued. Furthermore, wolf reintroduction programs have received energetic opposition from individuals and organizations (Lohr *et al.* 1996; Schoenecker and Shaw 2008). In the past, grizzly bears (*Ursus arctos*; Figure 5) were seen as either an aggressor, pest, or obstacle to human projects (Kellert *et al.* 1996). In western North America, mountain lions (*Puma concolor*; Figure 5) were subject to a pattern of persecution similar to that of the wolves. As the sheep and cattle empires expanded, so did the war on mountain lions (McCoy 1974). In Alberta, mountain lions became public enemies to harvest in order to accommodate growing hunting interest, reduce competition for resources, and minimize threat to public safety (Alberta Government 2012).

Large predators have been poisoned, trapped, snared, pursued by dogs, and shot from the ground and air (McCoy 1974; Cluff and Murray 1995; Proulx 2018a). Bounties (rewards offered for capturing or killing animals) were commonly used throughout Europe from the 17th to 20th century to control terrestrial predators (Proulx and Rodtka 2015). They were implemented in North America since European settlement (Mech 1970), and are still used in the western United States and Canada (Proulx and Rodtka 2015), although some of them are disguised as "incentive or culling programs" by government agencies. For example, unselective and inhumane killing neck snares are used in Alberta to "cull" wolves, and trappers receive bonus pay for each captured wolf, despite severe criticism by the scientific community (Municipal District of Greenview 2022).

Figure 5. Grey wolf (*Canis lupus*), grizzly bear (*Ursus arctos*), and mountain lion (*Puma concolor*) are being killed to accommodate big game hunting and allegedly reduce conflicts with livestock producers (Photos: Gilbert Proulx©).

Persecution is not limited to large carnivores. Mesocarnivores are also subject to many eradication efforts by landowners, farmers, and government agencies. Swift fox (*Vulpes velox*), American badger (*Taxidea taxus*), and long-tailed weasel (*Mustela frenata*) have all suffered from habitat loss, poisoning, trapping, and shooting in the Canadian Prairies (Herrero 2003; Proulx *et al.* 2016; Proulx 2021a). Nevertheless, the coyote (*Canis latrans*) has been the most persecuted mesocarnivore in North America (McCoy 1974; Flores 2016), and millions of them have been destroyed since the arrival of Europeans (Flores 2016) (Figure 6).

Figure 6. The coyote (*Canis latrans*) has been shot, snared and poisoned – it the most persecuted mesocarnivore in North America (Photos: Gilbert Proulx©).

Following lethal control, profound changes to social dynamics have also been observed in predator groups (Haber 1996; Wielgus *et al.* 2001; Cooley *et al.* 2009; Kilgo *et al.* 2017) and these changes may influence predator-prey dynamics. The removal of large predators may result in a cascade of ecological events that can destabilize wildlife communities and ecosystems (Estes *et al.* 2011; Bergstrom 2017) because large predators have the dual role of potentially limiting both large herbivores through predation and mesocarnivores through intraguild competition, thus structuring ecosystems along multiple food-web pathways (Ripple *et al.* 2014). Trophic cascades involving cougar, mule deer (*Odocoileus hemionus*) and either cottonwood trees (*Populus fremontii*) or black oaks (*Quercus kelloggii*) have been suggested by Ripple and Beschta (2006, 2008). Potential wolf-elk (*Cervus canadensis*)-aspen (*Populus tremuloides*) systems have also been identified by Beschta and Ripple (2007) and Painter *et al.* (2018). A sea otter (*Enhydra lutris*)-kelp (*Gyrista* spp.)-sea urchin (*Echinus* spp.) has been observed when the removal of sea otters from a kelp forest is followed by an expansion of sea urchins, their major prey, and the loss of kelp and other wildlife such as the kelpfish (different genera) and kelp crabs (*Pugettia producta*) (McLeish 2018). The mesopredator release of coyotes following a reduction in wolf densities has been associated with high rates of coyote predation on pronghorn (*Antilocapra americana*) (Berger *et al.* 2008).

The culling of carnivores is often based on false assumptions. For example, it has been hypothesized that moose (*Alces americanus*) harvests could be positively correlated with harvests of wolves and bears (*Ursus* spp.). However, 40 yrs of data have shown that this was not true in Alaska (Miller *et al.* 2022). In the last 2 decades, predation by wolves has been identified as the proximal factor causing the decline of woodland caribou populations in western Canada (Figure 7), and in Alberta, government biologists and some academics have argued that reducing wolf populations would save the boreal woodland caribou (Hervieux *et al.* 2014), an approach that was highly criticized by scientists (Brook *et al.* 2015). Also, when reviewing selected scientific references that were used to justify wolf culling programs, Proulx (2017c) found that predation by wolves represented <15% of boreal caribou mortalities. Furthermore, there was a major lack of wolf food habit studies within caribou range, thus suggesting that the wolf culling program was not based on scientific evidence.

Figure 7. A grey wolf (*Canis lupus*) culling program to save the endangered boreal woodland caribou (*Rangifer tarandus*) in Alberta was not based on scientific evidence and was highly criticized by scientists (Brook *et al.* 2015; Proulx 2017c) (Photos: Gilbert Proulx©).

For a long time, it has been believed that livestock losses would be reduced with increased predator control. However, >40 yrs of research on lethal and nonlethal interventions for reducing predation on livestock failed to confirm this assumption, largely because of poor experimental designs (Eeden *et al.* 2018). Decisions to use interventions were most likely based on subjective factors (e.g., ethics, opinions, or perceptions) or non-scientific (and thus possibly biased) evidence (Eeden *et al.* 2018; Treves *et al.* 2024). Wielgus and Peebles (2014) also found that the long-term effectiveness of lethal wolf control to reduce livestock depredations had not been rigorously tested. Predator removal results in a recolonization of vacant territories by animals from surrounding areas (Knowlton *et al.* 1999; Treves and Naughton-Treves 2005; Bailey and Conradie 2013; Kilgo *et al.* 2017), many of them being subadults with a greater propensity for livestock depredation than older animals (Peebles *et al.* 2013). Compensatory immigration, along with compensatory reproduction, may actually result in an increase in predator abundance and predation (Brainerd *et al.* 2008; Schmidt *et al.* 2017). Berger's (2006) analysis of a 60-yr dataset suggested that the control of coyotes to reduce sheep losses has been ineffective. In Alberta, bounties to kill coyotes and wolves have been implemented in various municipal districts since 2007 to allegedly minimize livestock predation. Between 2010 and 2015, more than 25,000 coyotes and 1,400 wolves were killed by bounty hunters in Alberta (Proulx and Rodtka 2015). However, during a 2-yr study of coyote and wolf food habits in agricultural counties, Proulx and Parr (2018) found that coyote and wolf spring and summer scats with cattle remains were found in areas with carcasses of cattle that had died of natural causes, and scats were likely the result of scavenging rather than predation (Figure 8). Similarly, in a recreation area of north-central Alberta, the Alberta Government approved a wolf culling program because livestock producers claimed that wolves were a threat for their livestock. However, a study of summer and winter wolf food habits showed that wolves fed mainly on wild cervids, and cattle was not an important part of their diet (Proulx and Villeneuve 2020). In southern Saskatchewan, producers used non-selective rodenticides to control Richardson's ground squirrels (*Urocitellus richardsonii*), and kill mesocarnivores through secondary poisoning (Proulx 2011), although studies have shown that long-tailed weasels (Proulx 2019) and American badgers (Proulx 2016) played an important role in the control of ground squirrels.

Figure 8. In Alberta, bounties to kill coyotes (*Canis latrans*) and grey wolves (*Canis lupus*) have been implemented in various communities since 2007 to supposedly minimize livestock depredation. However, Proulx and Parr (2018) showed that wild canids scavenged on carcasses of cattle that had died of natural causes. Spring and summer scats with cattle remains were the result of scavenging rather than predation. The coyote (insert) was neck-snared near a carcass and its paws were amputated for bounty compensation (Proulx and Parr 2018) (Photo: Gilbert Proulx©).

Many organizations and people may request that a killing predator management program be established to reduce or extirpate a population of predators that is in conflict with their personal or communal interests. However, surprisingly, often the identity of the predator species is unknown, and there is a lack of scientific evidence (Proulx 2018b). Identification of animals and of perceived problems based on anecdotal reports often are invalid and may lead to false conclusions. Instinctive fear of carnivores, particularly the large ones, and a negative attitude may be maintained or amplified by news presentations and social media, which are highly biased toward a graphic, sensationalistic view of predators (Nanni *et al.* 2020; Shiffman *et al.* 2020). Today, carnivores are still eradicated in many jurisdictions on the basis of prejudice and pressure by some lobbyist groups (e.g., Wielgus and Peebles 2014; Proulx and Rodtka 2015). Unfortunately, many of the world's pandemics, irruptions of undesirable species and collapses of desirable ones, and destabilization of ecosystems, have been caused by the loss of apex predators (Estes *et al.* 2011).

"Pest" control

Pesticides

Pesticides include herbicides, fungicides, insecticides, nematicides, rodenticides, predacides, etc. There is a lack of knowledge on the amounts of pesticides being used around the world (Gross 2014). In the last years, at least 2 million tons of pesticides may have been used annually (Sharma *et al.* 2019), although this estimate may be closer to more than 4 million tons in 2022 (Dutta and Bortamuly 2018; Zhang 2018; Worldometer 2022) (Figure 9). Top pesticide-consuming countries are China, USA, Argentina, Thailand, and Brazil (Sharma *et al.* 2019). The African continent has the lowest consumption, and the Asian continent, the highest (Sharma *et al.* 2019; Figure 9). Herbicides and insecticides are the most used, representing 47.5% and 29.5%, respectively, of all pesticides used (Sharma *et al.* 2019). Pesticides are used to increase crop productivity, but they are important contributors to air, soil and water pollution (Sharma *et al.* 2019) and, not surprisingly, they are a major threat to wildlife (Dubey and Sudhakar 2021)

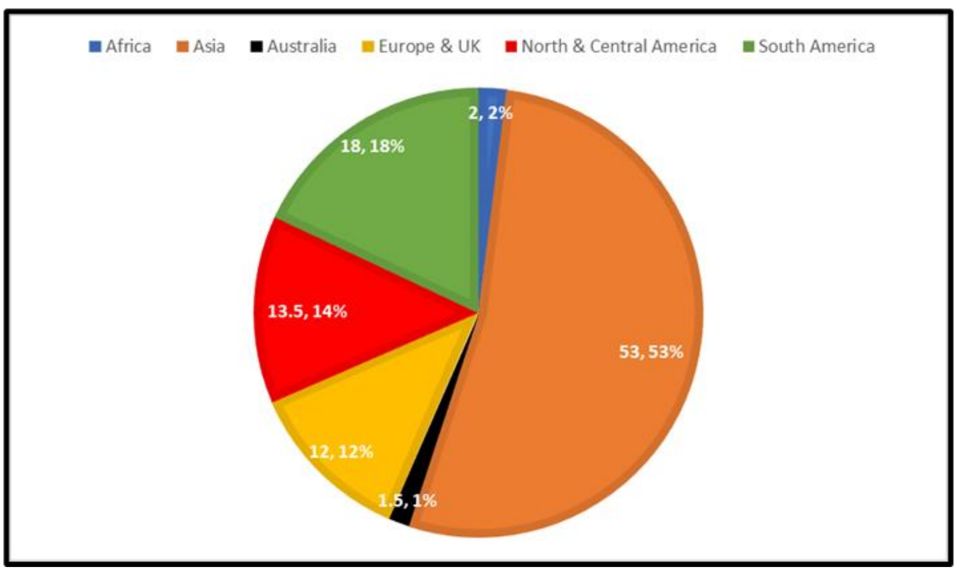

Figure 9. Proportions (%) of pesticides used per continent. Coarse estimates based on a worldwide consumption of 4,060,969 tons of pesticides in 2022 (based on Sharma *et al.* 2019 and Worldometer 2022).

Following the overuse of DDT in the 1950s (Carson 1962), many chemicals such as herbicides (MacKinnon and Freedman 1993; Karlsson *et al.* 2021), organochlorines (Mateo-Tomása *et al.* 2020; Torquetti *et al.* 2021), neonecotinoids (Gross 2014; Gibbons *et al.* 2015; Frank and Tooker 2020), strychnine (Proulx *et al.* 2015), Compound 1080 (Parr and Barron 2021), anticoagulants (Elliott *et al.* 2022), and many others (Ogada 2014; Kenko *et al.* 2017; Freitas *et al.* 2020) have raised serious concerns.

In Canada, agricultural pesticide (particularly herbicides) use has contributed significantly to the decline of SAR (Gibbs *et al.* 2009). In urban and agricultural areas, the extensive use of anticoagulants has become pervasive contaminants of terrestrial birds of prey (Schmutz 1987; Elliott *et al.* 2022). Although anticoagulants are extensively used for the control of fossorial rodents such as northern pocket gophers (*Thomomys talpoides*), they are not effective. They also fail to control Richardson's ground squirrels inhabiting alfalfa fields (Proulx 2014). However, they impact seriously on terrestrial predators and scavengers (Proulx 2010, 2014) and, along with strychnine baits, are responsible for population declines of American badger and red fox (*Vulpes vulpes*) (Proulx and MacKenzie 2012). Although strychnine has been found ineffective to control fossorial rodents (Proulx 2014), until recently, it was still used in agricultural lands. Strychnine was also used to kill wolves in Alberta, a method which does not meet Canadian Council on Animal Care (CCAC) guidelines because it causes long and painful deaths in animals (Brook *et al.* 2015; Proulx 2018a), and is unselective and impacts seriously on the integrity of wildlife communities (Proulx *et al.* 2015). Similarly, Compound 1080 is being used for the control of wild canids, but it also causes suffering and is non-selective (Parr and Barron 2021). Shockingly, until recently, the Government of Canada (2022b) was still uncertain about the continued approval of both strychnine and Compound 1080 as predacides.

Trapping

Rodents and carnivores are regularly trapped by landowners, farmers, and pest controllers. However, little concern about animal welfare and the adequacy of traps to humanely and selectively capture target species is being given by people (see Section on Animal Welfare, below). Also, international humane trapping standards are far from being representative of state-of-the-art technology (Proulx *et al.* 2020), i.e., they are sub-standards and they do not take into account new materials and mechanical systems, and they do not integrate proper animal welfare criteria. Traps for commensal rodents (mice and rats) are still unregulated, and cause pain and suffering (Baker and Sharp 2015). Bounty hunters and landowners use inhumane and non-selective killing methods such as shooting animals in non-vital regions, and killing neck snares, which are non-selective, and kill many non-target species, some of them at risk (Proulx and Rodtka 2015). Antiquated and inadequate trapping devices are still being used by people of all walks of life (Feldstein and Proulx 2022). Current checking times for killing traps and snares are inadequate or nonexistent in most North American jurisdictions (Proulx and Rodtka 2019). Obviously, there is a need to educate wildlife professionals, trappers, and the public (Stevens and Proulx 2022).

Pollution

Pollution is the introduction of potentially harmful chemical or physical constituents into the environment, in which substance significantly harm individual species, metabolisms, or alter an ecosystem composition (Preeti *et al.* 2018). Pesticides are pollutants that we reviewed in the section on pest control. However, wildlife is also facing a bewildering array of pollutants of various types that are released in the environment either intentionally or accidentally (Preeti *et al.* 2018; Aulsebrook *et al.* 2020): Persistent Organic Pollutants (POPs), industrial chemical products (polychlorinated biphenyls─PCBs, and hexachlorobenzene products─HCBs), oil spills and combustion causing acid rain, toxic metals such as cadmium (Cd) and lead (Pb), light, heat, and noise-pollution, radioactive wastes, and more.

In 2018, 55.3 billion tonnes of greenhouse gas emissions were emitted. Over recent decades, over 77% have come from the use of fossil fuels; about 23%, from land conversion and agriculture (Timoney 2021). Oil and gas industry is responsible for crude oil (a mixture of volatile and non-volatile hydrocarbons in combination with amounts of natural gas, carbon dioxide, saline water and sulphur compounds) and "saline produced water", a by-product of oil and gas productions. In Alberta, there are over 500,000 fossil fuel industry wells, 591,000 km of pipelines, well over 2 million km of seismic lines and hundreds of batteries, facilities, and processing plants, and 74,975 crude oil and saline water spills distributed across Alberta (Timoney 2021, 2024). This is only what has been reported to date. Indeed, Timoney (2021, 2024) warns readers about the truthfulness of these data. In fact, there are thousands of missing spills and reported spill rates and volumes are unreliable. Most spills and wildlife habitat losses are unknow to the public.

Plastics have become the curse of the 21st century. They can constrict or trap animals, be ingested, reduce oxygenation in the water, lower light penetration, cover coral reefs, and more. Microplastic and nanoplastic pollution plays a role in the proliferation and propagation of infectious diseases (Maquart *et al.* 2022).

Environmental pollutants can have direct impacts on reproductive physiology and development, and impact on gamete quality and function, sexual communication and selection, and parental care (Aulsebrook *et al.* 2020). PCBs are such pollutants with an impact on reproduction. They are found in air, soil, water and diverse biota, and they enter the food chain through the intake of animal or fish fats, and reach humans and wildlife (Beyer and Biziuk 2009). More than 35 yrs ago, Proulx *et al.* (1987) reported the presence of PCBs and other organochlorines in wild mink (*Neovison vison*) populations of Lake Erie, Ontario, Canada, at high enough concentrations to cause reduced reproductive success. Years later, PCB concentrations in Lake Erie mink populations are still elevated, adversely affect reproduction; also ≥ 2-yr-old mink are absent from populations (Martin *et al.* 2017). Although the use of PCBs has been banned in Canada since 1977, their persistence in the environment continue to impact significantly on wildlife species. As Gibbons *et al.* (2000) pointed out, "direct and indirect effects of environmental pollution, disease and parasitism, and global climate change are more difficult to quantify in many instances and will be more difficult to change in the short term."

Animal Welfare

The notion that animal welfare applies to wildlife has escaped many animal welfarists and conservationists (Paquet and Darimont 2010). The same human activities driving the current extinction crisis, e.g., loss of habitat integrity and persecution, are also causing suffering, fear, physical injury, psychological trauma, and disease in wild animals (Bradshaw *et al.* 2005; Gilbert 2019). In this section, I relate wildlife welfare to the health of the animals, i.e., the physical, behavioural and physiological conditions, affected by humane activities.

Inhumane trapping

Few subjects have generated as much emotions as mammal (furbearer) trapping. Since 1925, organized efforts to reform trapping were aimed primarily at reducing cruelty to animals, particularly by outlawing the steel-jawed leghold trap (Gerstell 1985; SCAAND 1986; Gentile 1987). Since then, the wildlife profession has witnessed an expansion of animal welfare groups, some with extremist views. Unfortunately, wildlife professionals, when confronted with the problem of "humaneness" in trapping, commonly remain passive (Proulx and Barrett 1989). It was true with steel-jawed leghold traps, and it is still true with killing neck snares (Proulx 2018a) and trapping standards (Proulx *et al.* 2020). Many professionals adopt the conservative approach of maintaining the *status quo* but this does not resolve the issue of humaneness in trapping. As Proulx and Barrett (1989) pointed out, "The issue of humaneness has surfaced generation after generation and now ‶inbred animal activists″ fight against ‶inbred wildlife biologists″".

The continued use of unacceptable trapping devices and the protection of the 'old ways' by some trappers, pest controllers and biologists are largely the causes of controversy in mammal trapping (Proulx 2022a). Concerns about mammal trapping led to denunciation of trapping devices such as killing neck snares (Proulx *et al.* 2015; Proulx and Rodtka 2017) (Figure 10), glue boards (Mason and Littin 2003), and steel-jawed leghold traps (Proulx and Barrett 1989) that do not meet any standard, and non-selective trapping devices that endanger the persistence of SAR (Virgós *et al.* 2016). The trapping standards of the

International Organization for Standardization (ISO, 1999a,b), the Agreement on International Humane Trapping Standards (AIHTS; ECGCGRF 1987), and the American Agreed Minute with the European Community (Anonymous 1998) have been severely criticized by Harrop (1998), Iossa *et al.* (2007) and Proulx *et al.* (2020). Trapping regulations (Proulx and Rodtka 2019) and predator control and research programs have been found inadequate, unjustified and unethical (Brook *et al.* 2015; Proulx and Rodtka 2015).

In Canada, although current AIHTS standards are inadequate and are not representative of state-of-the-art technology and animal welfare science, they are not even implemented by provincial wildlife agencies. As a result, steel-jawed leghold traps, which are the main cause behind the controversy of mammal trapping, are still being used by fur trappers (Feldstein and Proulx 2022). Improper trap testing is still being conducted in North America (Proulx *et al.* 2020) and elsewhere (Caravaggi *et al.* 2021); non-selective and inhumane traps are still being used in the wild (Proulx 2018a) and in urban and sub-urban areas (Stevens and Proulx 2022; Villeneuve and Proulx 2022); and the issue of cruelty in mammal trapping continues to be a problem in need of a solution.

Figure 10. This neck-snared coyote (*Canis latrans*) fought for 14 hrs before dying (Proulx 2018a). Note the swelling of the head and neck due to the presence of edema that is typical of neck-captured animals which do not die quickly (Proulx and Rodtka 2017) (Photo: Gilbert Proulx©).

Distressful pesticides

As I indicated in the section on pollution, a diversity of pesticides is being used globally to control animals and plants. In Canada, among poisons that are employed for the control of mammals involved in human-wildlife conflicts, the following ones are highly controversial because they cause pain and suffering: strychnine, sodium monofluoroacetate, and anticoagulants.

<u>Strychnine and sodium monofluoroacetate</u>

Strychnine is an alkaloid originating from the seeds and bark of the plants of the genus *Strychnos* (Proulx 2018a). Sodium monofluoroacetate, also called sodium fluoroacetate or more commonly referred to as Compound 1080, occurs naturally as a defensive compound in plants, namely in *Dichapetalum cymosum*, commonly known as gifblaar or poison leaf (Marais 1943, 1944). Both poisons cause suffering over a period of a few to several hours in animals that ingest them.

Strychnine causes unimpeded stimulation of motor neurons affecting all striated muscles of the body to produce generalized rigidity and tetanic seizures. Clinical signs include frequent periods of maximal muscle contractions (tetanic seizures), occasional cessation of breathing, rapid heart beat, and hyperthermia (Proulx 2018a). Victims who ingest Compound 1080 experience both physical and psychological terror caused by the recurrence and repetition of violent convulsions and seizures (Randall 1981; Sherley 2007). Sherley (2007) cites that clinical signs of severe pain and distress are evident in animals poisoned with Compound 1080; these include retching and vomiting, trembling, fecal and urinary incontinence, severe and prolonged convulsions, unusual vocalizations/screaming, hyperactivity, muscular weakness, incoordination, hypersensitivity to sensory stimuli, and respiratory distress. Eventually death results from cardiac failure, central nervous system failure, or respiratory arrest. The use of both poisons has been denounced by the Canadian Veterinary Medical Association (2014). After years of consultations with the public and professionals. Health Canada (under the authority of the Pest Control Products Act) cancelled all uses of strychnine. Strychnine can no longer be used to control predators (Health Canada 2024). However, Health Canada (2024) has determined that continued registration of products containing sodium monofluoroacetate was acceptable.

Anticoagulants

Anticoagulants are common pesticides used by people in urban and sub-urban settings, and agriculturists in fields and near infrastructures. Since their introduction in the late 1940s and early 1950s, anticoagulants have been used to replace acute and hazardous poisons, and revolutionize control programs (Meehan 1984; Berdoy and Smith 1993; Meerburg *et al.* 2008). Anticoagulants must be consumed over a number of days before a lethal dose is reached. They inhibit the production of clotting agents in the rodent's liver, resulting in death due to internal haemorrhages (Bell and Caldwell 1973; Thijssen *et al.* 1986). Death usually occurs 5–15 d after bait consumption. Anticoagulants are generally considered to induce animal suffering (Kirkwood *et al.* 1994). Rodents remain conscious between the time of poisoning and death, and during that time, haemorrhages in vital organs (e.g., lungs, kidneys) caused by anticoagulants can lead to serious discomfort through the accumulation of blood (Broom *et al.* 1999). Abdominal pain forces the animals to adopt a curled up/hunched posture with lowered head, to walk slowly and unaware of their surroundings, and to lay down, conscious and immobile. Although anticoagulants are known to cause severe pain and suffering, they are still being used everywhere. Anticoagulants are indiscriminate, and through secondary poisoning, they kill many predators and scavengers feeding on moribund poisoned animals and carcasses (Proulx and MacKenzie 2012; Proulx 2014).

Invasive alien species

Biological invasions are a global consequence of an increasingly connected world and the rise in human population size. The numbers of invasive alien species, i.e., those whose presence in a region is attributable to human actions, deliberate or inadvertent, that enabled them to overcome biogeographical barriers (see review by Pyšek *et al.* 2020), are increasing. There are thousands of invasive alien plant, invertebrate, fish, bird and mammal species throughout the world (Pyšek *et al.* 2020).

Alien invasive species have a major economical impact on human communities, e.g., outbreaks of rodents such as Norway rats (*Rattus norvegicus*) associated with substantial damage to agriculture, forestry, urban infrastructures, and transmission of diseases to humans (Witmer and Proulx 2010). A large proportion of alien invasive species are associated with disturbed anthropogenic habitats such as urban areas, agricultural landscapes, transportation and communication corridors, and industrial developments (Langor *et al.* 2014). And many of these species are a leading cause of animal extinctions (Clavero and García-Berthou 2005). Canada is not immune to the presence of alien invasive species, and as a signatory to the international Convention on Biological Diversity (CBD), it has committed to prevent, control, and eradicate invasive alien species (Smith *et al.* 2014).

However, many of the alien native species inhabiting a diversity of ecosystems have received insufficient attention from wildlife management agencies. This is the case of wild pigs (*Sus scrofa*; Figure 11), which are descendants of Eurasian wild boar (*S. s. scrofa*) brought over from Europe and Asia, and domestic pigs (*S. s. domesticus*). Farmed wild boars either escaped captivity or were released and interbred with domestic pigs (Michel *et al.* 2017). Domestic wild boars were brought into Canada in the 1980s (Michel *et al.* 2017) to diversify agricultural production (Brook and van Beest 2014). The widespread success of wild pigs is the result of their extremely high fecundity in Canada (Koen *et al.* 2018), early sexual maturity (Gethöffer *et al.* 2007), flexible diet (Barrios-Garcia and Ballari 2012), and highly adaptive nature that allows them to thrive in a broad range of habitats (Seward *et al.* 2004). Wild pigs alter ecosystem processes, vegetation successional stages, nutrient cycles, and cause erosion, sedimentation, and eutrophication to riparian areas and water bodies (Figure 11), as well as direct and indirect impacts on species at risk and other wildlife (Barrios-Garcia and Ballari 2012; Bevins *et al.* 2014; O'Brien *et al.* 2019). While there is an obvious need to control the wild pig invasion (Villeneuve *et al.* 2022), control programs such as bounties are promoted by some wildlife agencies (Alberta Government 2022) and are totally ineffective. On the positive side, the Alberta Pork Producers Development Corporation (Alberta Pork) wants all counties in the province to gradually start prohibiting wild boar. On the negative side, however, an Alberta County has already rejected a request to approve a proposed animal control bylaw prohibiting wild boar within its borders, instead preferring to continue to manage the animals under the provincial Agricultural Pests Act (Ferguson 203).

Figure 11. Wild pig (*Sus scrofa*) rooting, wallowing, and trampling damage vegetation and riparian areas, and impact on wildlife species habitats (Photos: Gilbert Proulx©).

Socio-political interests and bad management

The negative impact of politicians and their agendas on wildlife conservation is global. For example, in the UK, there is a lack of political will to resolve conflicts over predator management, and political pressures may override scientific advances (Thirgood and Redpath 2008). The same happens in Norway over illegal wolf hunting (Skogen and Grange 2020). In the State of Washington, USA, instead of holding a powerful and politically connected rancher responsible for his actions that led to increased livestock depredation, the government publicly defended this rancher and continued to kill wolves on his behalf (Solomon 2018; Wielgus 2018).

The Idaho legislature in the 1980s prohibited state involvement in the reintroduction of wolves, and in 2001 resolved to eradicate wolves from the state (Bergstrom *et al.* 2009). In 2011, the removal of the northern Rocky Mountain gray wolf from the federal list of endangered and threatened wildlife was a response to political pressure and was unjustified according to the best available science (Bergstrom 2011). During Montana's last legislative session, in 2021, Governor Gianforte — with the help of handpicked wildlife commissioners representing trophy hunting, outfitting, and livestock industries — signed bills to deregulate wolf-hunting techniques. The state also did away with hunting quotas on the northern border of

Yellowstone National Park, leading to the deadliest winter the park's biologists have ever recorded, with roughly a fifth of Yellowstone's wolves killed in a matter of months (Deveraux 2023).

In Zimbabwe, elephants have been victims of politically controversial conservation decisions (Duffy 2000). Illegal wildlife trade in Russia has been tied to a corrupted political system (van Uhm and Moreto 2017). Bear bile "farming", where long metal catheters are surgically implanted into the bear's gall bladder to ensure a continuous supply of bile used in traditional medicine, is a lucrative industry causing excruciating pain to the animals. It is popular and has free reign in South and North Korea, Vietnam and China (Davies 2005).

In Canada, the woodland caribou is an example of a species which is threatened and suffers from bad management and political decisions. The demise of caribou in Canada is the result of human activities. Caribou have suffered from habitat loss and fragmentation (Thomas and Gray 2002; Proulx 2015; Hebblewhite 2017; Figure 12), and degradation due to oil and contaminant spills (Timoney 2021), weather, starvation, diseases and parasites (Proulx 2017c), poaching and recreational activities (Proulx 2017c), and more. Politics may cause the killing and suffering of animals, as is currently happening in the Province of Alberta, Canada where politicians identified the grey wolf as the "fall guy" for the decrease of the Little Smoky boreal woodland caribou population which inhabits muskegs; thus, wolves were indiscriminately poisoned with strychnine (Brook *et al.* 2015). Contrary to the Government's anecdotal claims that wolves were too numerous, the number of wolves in the province is unknown (Proulx *et al.* 2017). No studies have shown that wolf numbers were too high and were limiting the Little Smoky caribou population (Proulx 2017c). Whereas muskegs and pine stands provide caribou with abundant food and cover, the muskegs' difficult terrain, deep snowdrifts and vertical cover protects caribou from wolves which do not venture into undisturbed muskegs for hunting (Proulx 2015; Proulx *et al.* 2017). The decision to kill wolves to save the Little Smoky caribou population was a politically expedient approach to protect industry from any habitat management program that could impact on exploitation activities (Proulx *et al.* 2017), and avoid the loss of revenues to Albertans (Boutin 2017; Fitch 2019). The current amount of undisturbed habitat in the Little Smoky is far below what is needed for caribou viability (Proulx 2017c), and the provincial political party opted to kill wolves and lose caribou rather than endangering forestry and oil and gas exploitations, and jeopardizing their voting base − the demise of caribou populations in Alberta will simply go down as an unfortunate by-product of progress (Foran 2018; Fitch 2019). The view that caribou conservation must "not unduly impact industry" (Alberta Government 2017) defines corporate profit as the bottom line and amounts to a death warrant for many caribou populations (Timoney 2021). Interestingly, a similar wolf-cull program was implemented in British Columbia, Canada. Despite warnings that industrial resource extraction, primarily forestry, was detrimental to maintaining viable caribou populations, and wolf control was ineffective as a control measure (Harding *et al.* 2020), wolves were scapegoated again by politicians.

The North American Model of Wildlife Conservation

Canada is a responsible country when it comes to environment, and it is signatory on international treaties and conventions such as the Migratory Bird Treaty, the Convention on International Trade in endangered Species of Fauna and Flora (CITES), the Ramsar Convention on Wetlands (RAMSAR), the Agreement of International Humane Trapping Standards (AIHTS), and may others. The federal government oversees the Species-at-Risk Act, and the management of marine species. However, responsibility for wildlife conservation and management is largely overseen by provinces and territories. Natives have jurisdictions over their lands. When implementing wildlife management programs, government agencies must often work together. However, disagreements and inaction often result from inter-governmental consultations.

Similarly, in the United States, wildlife management involves inter-agency consultations, i.e., between the federal government and the individual states. The federal government has a suite of agencies within the Department of the Interior, Commerce, Environmental Protection, and Department of Defense which are active throughout the country. Wildlife conservation includes most terrestrial and aquatic species. As in Canada, consultation among government agencies is complicated and complex, and divergent opinions often result in inaction, improper action and retroaction.

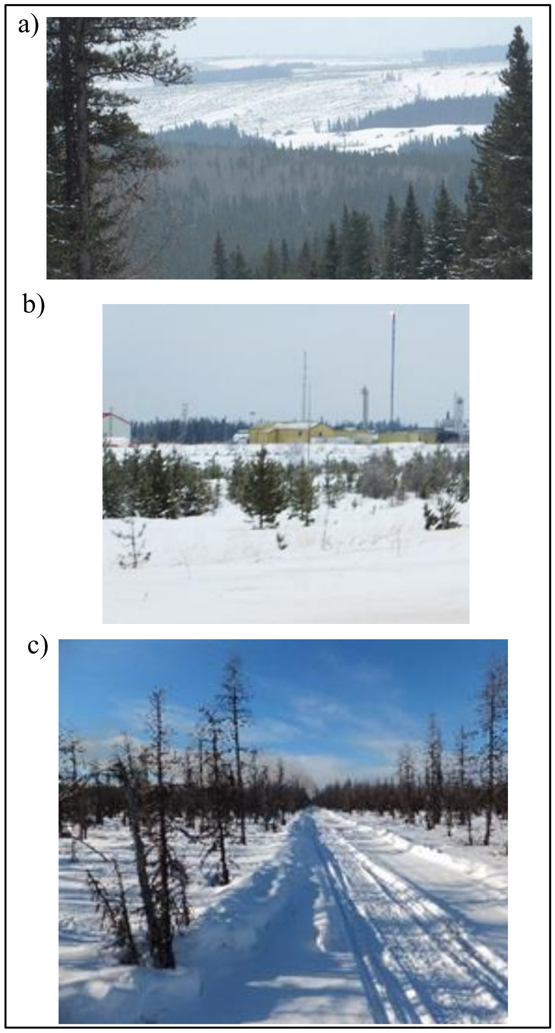

Figure 12. The demise of the Little Smoky caribou population in Alberta is the result of habitat destruction and fragmentation by: a) forestry, and b) oil and gas industries (Photos: G. Proulx©).

Complexities of Canadian law and tradition have made apparent to wildlife managers that effective conservation programming requires close consultation among jurisdictions (Organ *et al.* 2012). For decades, the annual Federal-Provincial Wildlife Conference (1983) and the Wildlife Ministers' Council of Canada (1990) were an opportunity for these jurisdictions to meet and discuss the general direction in which wildlife conservation should move in years to come. Although these consultations no longer exist, and have been replaced by scheduled meetings among wildlife agencies, they provided wildlife managers with a special focus on principles to follow. The principles listed by the Federal-Provincial Wildlife Committee (1983) and the Wildlife Ministers' Council of Canada (1990) were largely oriented toward the stewardship of habitats and populations by all Canadians, the democratic multi-use of wildlife, and the conservation and management of wildlife for the benefit of all Canadians. Today, The North American Model of Wildlife

Conservation (thereafter, The Model) has been adopted, in part or as a whole, by many wildlife specialists and wildlife agencies of provinces and states (Organ *et al.* 2012; Feldpausch-Parker *et al.* 2017). Also, Organ *et al.* (2010) believe that a U.S.-Canadian treaty securing The Model and improvements in wildlife law would be the most powerful from of protection.

The Model consist of 7 principles that recognize that 1) Wildlife resources are a public trust; 2) Markets for game are eliminated; 3) Allocation of wildlife is by law; 4) Wildlife can be killed only for a legitimate purpose; 5) Wildlife is considered an international resource; 6) Science is the proper tool to discharge wildlife policy; and 7) Democracy of hunting is standard. Although The Model first appears as a solution to today's wildlife management and conservation concerns, it fails to address most of the issues that I raised in previous sections. Furthermore, these 7 principles are largely oriented towards hunting, and fail to address today's biodiversity concerns.

Wildlife resources are a public trust

This component implies that wildlife is owned by no one and is held by government in trust for the benefit of present and future generations (Organ *et al.* 2010). However, in the previous sections, I repeatedly showed that many government decisions and programs did not aim at maintaining wildlife for future generations. In fact, The Model definitely emphasizes consumptive activities, particularly hunting, at the expense of other issues related to non-game species, biodiversity conservation (i.e., habitat loss, climate change, pollution), and animal welfare. The Model also fails to address the plight of SAR, the impact of politics on the listing (and delisting) of species, and the lack of conservation law enforcement at state and provincial levels. In fact, if The Model was so effective in ensuring the future of wildlife species for generations to come, the number of SAR should not have dramatically increased in the last decade, and recovery programs and long-term conservation measures would have been implemented across the land. More measures to counteract the impact of climate change on habitats would be implemented. Relentless human-wildlife conflicts involving predators would have been properly addressed to help ranchers and hunters, but also maintain diversified wildlife communities for future generations. The Model is concerned with the protection of property and the well-being of humans. However, it fails to justify more than one century of ineffective predator control programs and the lack of implementation of non-lethal management programs to ensure the integrity of wildlife community and ecosystems. Although many solutions exist to address multiple human-wildlife conflicts, The Model fails to mention the implementation of programs that do not require the services of hunters and trappers.

There is no explicit treatment on the importance of habitat conservation to wildlife management in Geist *et al.* (2001). Surprisingly, Organ *et al.* (2012) claimed that there was a lack of consensus within the wildlife conservation and management profession as to whether the concept of habitat conservation and the role of the private landowner rise to the level of a principle in The Model (Organ *et al.* 2012). The Model unquestionably fails to address habitat loss, and because wildlife cannot persist without habitats, hunting and trapping activities cannot be maintained.

Markets for game are eliminated

Wildlife biologists develop programs to monitor the biological status of harvested species and there is no doubt that they really try to maintain viable populations (Proulx 2022a). However, this component of The Model is deceiving. First of all, fur trade, game farms, outfitter licenses, and hunting safaris still exist today and are examples of game markets. Second, despite the claim that populations are managed sustainably through strict regulations such that the impacts on population fluctuations lie within natural ranges, there are plenty of examples where such management does not happen and populations continue to be harvested. For example, most populations are managed for sustained yield whereby, in theory, a maximum number of bears can be killed each year by humans, without causing population declines. However, uncertainty in mortality limits is only partially addressed by managers, and "true" mortality limits might be lower than suggested (Artelle *et al.* 2013). Artelle *et al.* (2014) found that between 2001 and 2011, in half of all hunted grizzly bear populations, human-caused deaths of grizzlies exceeded mortality rates deemed sustainable by government biologists. Nevertheless, the government reopened hunting in previously overharvested populations. Likewise, although Mowat *et al.* (2020) found that wolverine trapping was not sustainable due to habitat fragmentation, poor connectivity and few large refuges, trapping still went on. Regulations require mandatory reporting of captures and established a quota of 1 animal per trapper (B.C. Government 2022). Such measures may not be enough, however, to protect wolverines from overharvesting. Wolverines have a low resiliency to trapping because they occur at low densities and their home ranges are relatively large (Banci and Proulx 1999). In Oregon, given the small population size of the rare Pacific marten (*Martes caurina humboldtensis*) and its vulnerability to trapping, eliminating fur harvest in the central coast would decrease immediate risk of marten extirpation (Linnell *et al.* 2018). But Oregon still permits a limited trapping season for all martens (Oregon Fish & Wildlife 2022). Northern river otter (*Lontra canadensis*) populations in the U.S. have recovered substantially over the last 40 yrs through the advent of reintroduction projects in 22 states and natural expansion of remnant populations (Bricker *et al.* 2022). Also, expansion of river otter trapping followed the reestablishment of river otter populations. However, trapping seasons overlap with otter presumed parturition periods (Serfass 2022). Furthermore, because river otters often occupy beaver (*Castor canadensis*) flowages and infrastructures, they are often captured in traps intended for beavers. The harvest of river otters may not be sustainable, and some river otter populations may once again be extirpated.

According to Organ *et al.* (2010), regulated hunting and trade could enhance public appreciation of hunting as a management tool by reducing human-wildlife conflicts with overabundant species such as white-tailed deer (*Odocoileus virginianus*) and Canada goose (*Branta canadensis*). However, this argument is open to discussion because not all residents support hunting on their lands (e.g., Storm *et al.* 2007). There may be little or no public support for lethal wildlife management depending on management circumstances (Koval and Mertig 2004; Hadidian 2015; Lute and Attari 2016), and hunting may sometimes alter the age structure of populations (e.g., mountain lions) and trigger increased conflict where conflict-prone juveniles are involved (Teichman *et al.* 2016). Nevertheless, wildlife conservation can often be achieved without hunting and trapping. While these consumptive activities have their place in human-wildlife relationships, and may be used to meet some wildlife management objectives (Proulx 2022a), they should not be at the center of a wildlife conservation model.

The Model fails to address the SAR issue. In fact, because The Model largely promotes hunting and trapping in wildlife conservation, threatened or endangered species may be delisted to accommodate some interest groups, and such delisting may not be based on scientific evidence. The delisting of wolves, which are still threatened by human activities and have not recovered in many regions, suggests a poor understanding of what species recovery entails (Carroll *et al.* 2020), and is an example of how The Model was not effective in ensuring the perseverance of a species across its original distribution. In this case, the delisting may have been a last-minute gift from the Trump administration to conservative voters, particularly hunters, trappers, and livestock owners right before the November 2020 presidential election (Fears 2020; Fitzgerald 2022). The same arguments could be made for the 2017 delisting of the grizzly bear in Yellowstone (National Parks Conservation Association 2018; Bloomfield 2020).

Allocation of wildlife is by law

Organ *et al.* (2010) argued that, as a trustee, government manages wildlife in the interest of the beneficiaries—present and future generations of the public. Access and use of wildlife is therefore regulated through the public law or rule-making process. However, examples of poor wildlife management by government agencies presented in the previous sub-section show that governments do not always manage wildlife for present and future generations of the public. As Organ *et al.* (2012) admitted, "Although the U.S. and Canada have led the way in advancing the wildlife profession, wildlife management itself appears to be increasingly politicized". Many governmental priorities supersede wildlife conservation and management concerns, and often result in a poor protection of habitats and species (Proulx *et al.* 2017; Canadian Parks and Wilderness Society 2021).

Wildlife can be killed only for a legitimate purpose

Food, fur, self-defence, and property protection are generally considered legitimate purposes for the taking of wildlife (Organ *et al.* 2010). Unfortunately, these purposes often are misused to justify the removal of wildlife or the destruction of habitats. The continuous and ineffective use of predator lethal control programs (Musiani and Paquet 2004; Bergstrom *et al.* 2014; Proulx and Rodtka 2015), "wolf-wacking" (Boynton 2019), the annual coyote (Smith 2014) and rattlesnake (*Crotalus* spp.; Schipani 2018) killing derbies, are all examples of how wildlife is not killed for legitimate purpose, even though participants claim that such kills aim at protecting people and their property. These killing contests do nothing to improve wildlife conservation. Similarly, Saskatchewan decided to introduce a new wolf hunting license as an add-on to the non-resident outfitter big game hunting license. The population of wolves may have had less to do with the decision than a chance to appeal to the market in a different way (Mahon 2023). Thus, wolves will not be killed for a legitimate purpose.

Wildlife is considered an international resource

The protection of migratory birds and the protection of animals living in neighboring countries, and participation in international agreements such as CITES, are initiatives that are adopted and promoted by The Model. On the other hand, The Model fails to properly ensure the humane, selective and efficient capture of mammals at national and international levels. Such wildlife management concerns are not even mentioned in any of its principles even though the implementation of humane and effective furbearer trapping techniques has been a recurring subject in the last decades (Proulx and Barrett 1989; Proulx *et al.* 2020). Similarly, The Model fails to properly address the animal and habitat conservation problems and challenges caused by air and water pollution, and the 'forever chemicals' and plastics found in animals around the world.

Science is the proper tool to discharge wildlife policy

The Model properly recognizes that conservation and management programs should be based on scientific evidence. In reality, most wildlife biologists likely support this approach. Unfortunately, the maintenance of programs to appease lobbyist groups and please politicians, and the maintenance of harvest programs that impact significantly on the persistence of some wildlife populations, show that wildlife conservation and management programs are not always based on scientific evidence. Examples of decisions and programs that were not based on scientific evidence are numerous and impact on the recovery of SAR (Proulx and Brook 2017; Proulx *et al.* 2017), the harvest and control of predators (Artelle *et al.* 2014; Bergstrom *et al.* 2014; Proulx and Rodtka 2015), and the implementation of animal welfare criteria (Proulx *et al.* 2020). Factual scientific evidence should be a mandatory component of all wildlife conservation and management models. Unfortunately, contrary to Organ *et al.*'s (2012) claim, wildlife use is not always based on proper surveys (Proulx 2017c), population dynamics (Artelle *et al.* 2013), behaviour and habitat studies (Merrick and Koprowski 2017), animal welfare science (Proulx *et al.* 2020), and structured decision making (Proulx 2018b).

Democracy of hunting is standard

This component of the Model does not address true concerns in wildlife conservation and management. While hunting and trapping may be used in some wildlife management programs, the future of wildlife populations and habitats does not depend on hunting or trapping (Proulx 2022a). Long-term losses of biodiversity and shifts in public values demand a broader vision for the purpose of wildlife conservation (Bruskotter *et al.* 2022). Organ *et al.* (2012) claim that hunters and anglers remain the primary source of conservation funding at the state level. This is not true. Major contributions have been made in the past by the National Audubon Society, Defenders of Wildlife, The Nature Conservancy, and The Wilderness Society (Peterson and Nelson 2017; Serfass *et al.* 2018). Further, users other than hunters and anglers contribute significantly to conservation and include bird and other wildlife watchers, outdoor photography, and hiking (USFWS 2016). Smith and Molde (2015) estimated that the non-hunting public contributed about 95% of an annual $ 18.7 billon US cost associated with federally-managed public lands. One can wonder if the funds derived from user fees paid by hunters equate to the philosophical support for conservation that extends beyond hunting (Serfass *et al.* 2018). One must also question the impact of The Model on the involvement of non-hunting wildlife enthusiasts, policy makers, and wildlife professionals for more actively engaging in the process of developing policies pertinent to wildlife conservation (Feldpauch-Parker *et al.* 2017).

Overall

The Model and its 7 principles have been repeatedly portrayed as the "cornerstone" of wildlife conservation in North America (Heffelfinger *et al.* 2013). I believe that The Model is not in concert with societal needs, it is largely irrelevant because it is narrow in scope as it focuses almost entirely on game species and hunting, and it does not address the complexities of today's wildlife conservation and management. Further, The Model's principles fail to address the wildlife conservation and management issues that I identified in previous sections.

A series of points to ponder

The issues presented above relate to both conservation and wildlife management. Although some are the result of poor decisions made by managers, e.g., pesticides, trapping standards, invasive species, they all have an impact on wildlife conservation. Independent of the issues, solutions should be based on factual evidence and best available science. Conserving wildlife in the 21st century is a daunting task, one that absolutely demands the involvement and support of a much broader constituency of wildlife enthusiasts than just hunters (Serfass *et al.* 2018). Furthermore, win-win solutions that both conserve biodiversity and promote human well-being are difficult to realize (Robinson 1993; McShane *et al.* 2011), but they do exist (see Proulx 2021a).

The following consists of a series of points to consider when searching for solutions for the issues that I described above. These points are not exhaustive solutions and each of them would likely deserve its own monograph to review the pros and cons of what I propose. Hopefully, these points to ponder will be thought provoking and will engage further discussions among wildlife professionals.

Proper procedures

Many of the issues listed above are the result of poor procedures that are ineffective in time and space, and do not resolve the underlying cause of said problem. In the following, I propose a series of procedures for SAR, human-wildlife conflicts, predator control, and humane and selective mammal trapping, and alternatives to the technologies currently used to study wildlife in their environment.

Species at risk

Species-at-risk lists are valuable tools to inform conservation decisions when used appropriately. However, inherent problems (bias, legislative requirements, data discrepancies, poor implementation of recovery recommendations) associated with current listing and recovery processes exist in Canada (Farrier *et al.* 2007; Dorey and Walker 2017).

The first step is to improve upon the timeline to determine the status of a species and implement a recovery program (Figure 13). The actual COSEWIC process leading to the development and implementation of a recovery plan typically exceeds 96 mo (Figure 2). In a new accelerated and effective proposed process, status determination and recovery implementation could be achieved within 30 mo (Figure 13). The proposed process reduces the number of committee reviews, and employs wildlife specialists from the beginning to develop a species status report and recovery plan with budget and timelines. Government officials have a much shorter deadline to review the recommendations and make a decision. The reason for truncated timelines is to avoid that the status of the SAR worsens during the period necessary to assess and assign a status to the species. It is noteworthy to mention that Turcotte *et al.* (2021) proposed an automatic listing process based on biological evidence alone to avoid political interference. Thus, every COSEWIC-listed species would receive at least some level of protection. However, automatic listing may not be acceptable when factual datasets are limited, particularly when socio-cultural impacts may significantly affect people and livelihoods. Turcotte *et al.* (2021) suggested that if automatic listing is too politically problematic, a potential alternative could be automatic prohibitions where no additional activities impacting on the species of concern are allowed while a listing is pending.

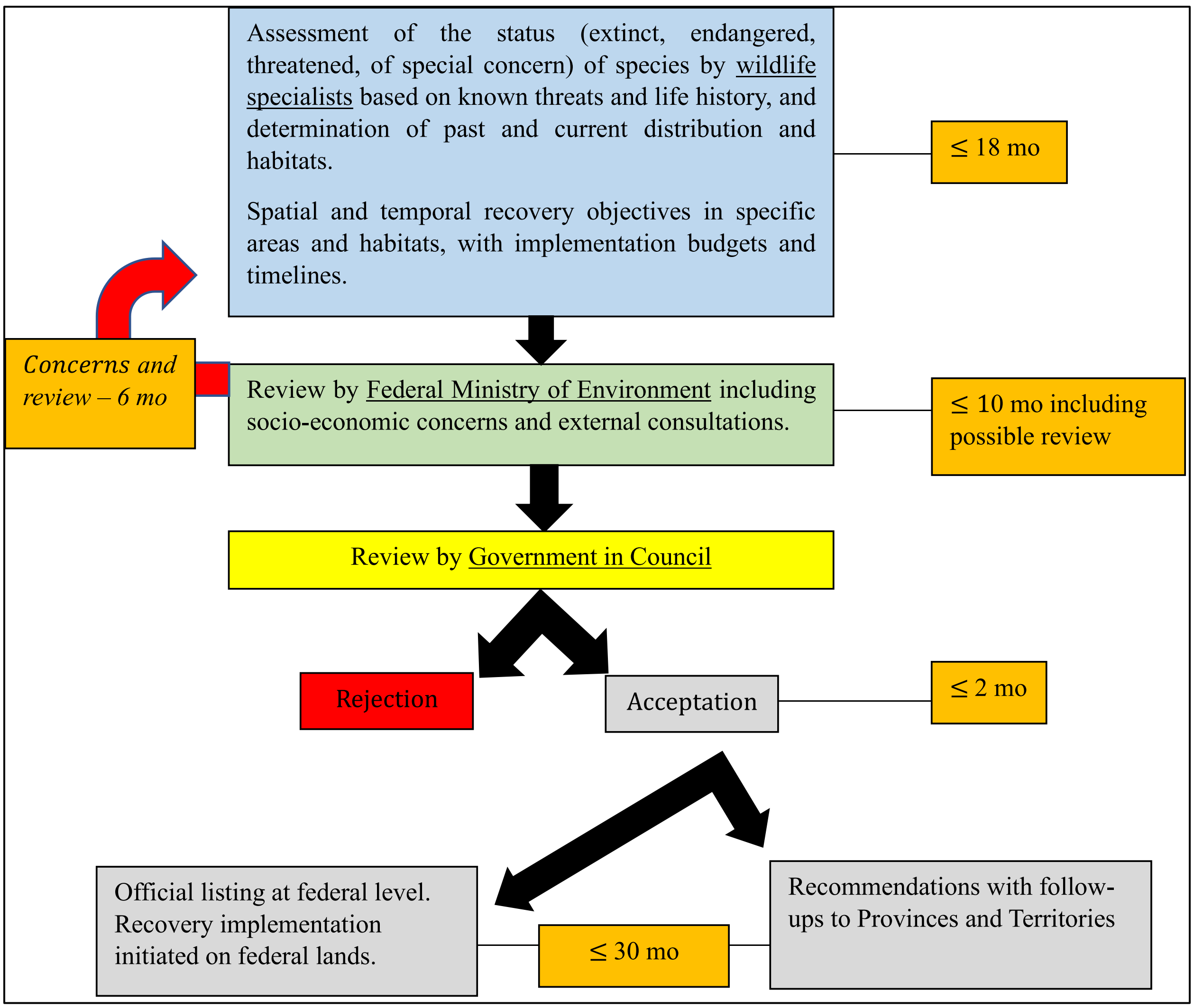

Figure 13. Schematic representation of a faster and more effective COSEWIC process.

The implementation of the new process that I propose would require the following prerequisites: 1. A large enough budget is necessary to retain wildlife specialists – Contrary to the usual governmental process where allocation of contracts is often based on the lowest bid, the selection of professionals should be based on knowledge and expertise, and capability to deliver expected results on time. Wildlife specialists should be sought among university professors and their graduate students, and professional consultants, as long as they have the credentials to carry out the work. Expertise is essential here. The survival of species is at stake and one should not allocate a contract to students and professionals who do not have any history with the candidate species.

2. Delays are unacceptable – The budget must provide the funds for the recovery of the species. There is no point in listing a species as endangered, threatened or of special concern if not actions are immediately taken to remediate the problem. Of course, prioritization of actions is necessary depending on the status of species, i.e., there is more urgency in recovering an endangered species than a threatened species or a species of special concern. However, the committees must understand that delays in processing a species may result in greater endangerment of this species over time (e.g., Martin *et al.* 2012). With the actual COSEWIC process, a species of special concern could really become threatened over the 8-yr period required to initiate any recovery action. The SAR prioritization process could be further improved if species designations and recovery plans would integrate species with similar habitat requirements to produce a multi-species management plan (Proulx 2005a). Inclusion of Indigenous representatives in multi-species committees that use the "Two-eyed seeing" approach, i.e., addressing the issue with one eye embracing the strengths of Indigenous Knowledge and the other eye incorporating that with Western Knowledge (Abu *et al.* 2018; M's-it No'kmaqa *et al.* 2021; Meng *et al.* 2024), and field data such as Inuit harvest data (Kowalchuk and Kuhn 2012) would further enhance the quality of the recovery process.

3. Wildlife is the priority – Although economic contexts often change over time, a quicker and effective species-at-risk program should take into consideration the statements of the Federal-Provincial Wildlife Conference (1983) and the Wildlife Ministers' Council of Canada (1990) that "the maintenance of viable natural wildlife stocks always takes precedence over their use". Delays in the implementation of the SAR program cannot be justified by a slow and ineffective bureaucratic process, or politically motivated concerns. Time is of the essence and actions must be taken in as brief a delay as possible.

4. Actions must be taken at national level – Although the federal government actions may be applied to federal lands only, the federal ministry of environment should be able to obtain more effective and timely actions at provincial and territorial levels (Figure 13). Funding is often an issue for provincial and territorial jurisdictions, and this must be effectively recognized by government departments, as I will discuss in the subsequent sub-section on Planning Principles. Not listing, and subsequently protecting, a species because of cost undermines the Convention on Biological Diversity objectives, which SARA is mandated to follow (Dorey and Walker 2017). Also, SARA prohibitions may be applied to protect any listed species found on private lands, provincial lands or lands within a territory, if provincial/territorial laws do not effectively protect the species or its residence, although the federal government rarely enforces this measure. When it considers implementing it, the government is quickly challenged by industry which feels that its wellbeing is more important than that of the SAR (Ross 2023).

5. Basic information on a species habitat must be used immediately – Delays in the implementation of recovery plans often are related to a lack of critical habitat definition (Camaclang 2014; Bird and Hodges 2017). Critical habitat should be defined operationally as the habitat required to ensure the persistence of a species or a population (Murphy and Noon 1991; Hall *et al.* 1997; Rosenfeld and Hatfield 2006). However, data about the relationship between habitat and population viability, the target population size and long-term population viability, and the amount and location of habitats needed to achieve the desired targets (Pulliam and Danielson 1991; Rosenfeld and Hatfield 2006) may not be available. Also, it is difficult to determine how much habitat is critical for long-term persistence, including the proportion of unoccupied habitat that might be required for recovery. Furthermore, evidence of the effectiveness of critical habitat designation to date has been mixed (Schwartz 2008; Gibbs and Currie 2012). On the other hand, specialists who are involved in the determination of the status of a species know about the distribution of the species and the habitats that are used by this species. This basic information alone can be used to determine locations and habitats that require immediate protection. The designation of critical habitat may therefore be made in the absence of perfect information, and can be updated and refined as new information becomes available (Camaclang *et al.* 2014) through new research. Designation of critical habitats should

be done even in the face of incomplete information because of the significant negative consequences that can result from failure to protect the habitat of SAR (Bird and Hodges 2017).

Human-Wildlife Conflict

For decades, solutions to the human-wildlife conflicts have unfailingly consisted of lethal programs and such programs have been repeated year after year with consistent meagre results that negatively affect wildlife communities. We need to change our response to conflicts. In a world where economics generally dominate management decisions, wildlife biologists must link the benefits and costs of wildlife conservation with those of human societies and activities (Proulx 2021a).

When a human-wildlife conflict surfaces, one should not automatically implement a lethal program. Solutions to human-wildlife conflicts are multi-faceted and they involve various natural and anthropogenic factors (Proulx 2021a). I therefore recommend a stepwise approach to assess and resolve a conflict (Figure 14).

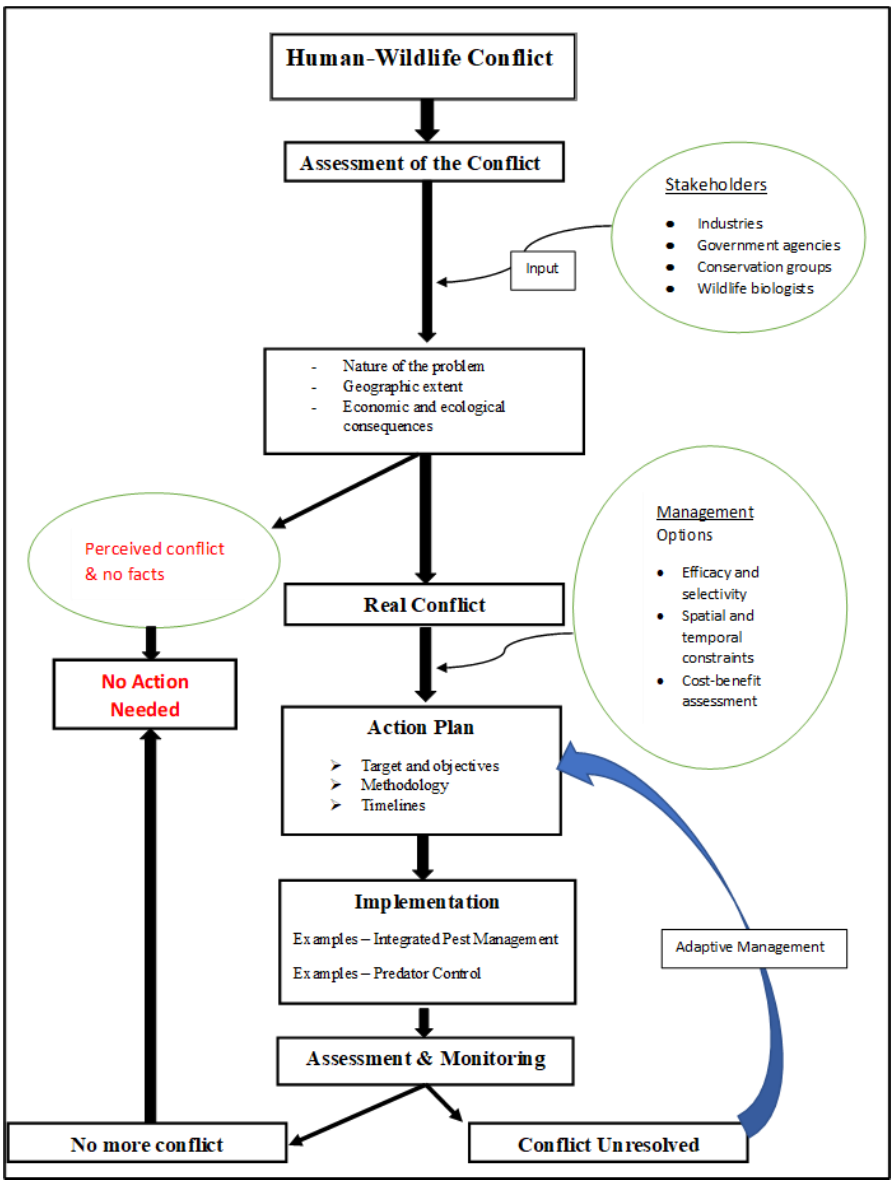

Figure 14. Stepwise approach to assess and resolve a human-wildlife conflict (after Proulx 2021a).

The problem must first be assessed and ascertained by reviewing the issue with stakeholders, reviewing available datasets and any available proof, and conducting field surveys and inspections (Figure 14). If actions must be taken, they must be properly selected in order to properly resolve the conflict and not impact on wildlife communities and ecosystems. More field surveys and inspections should be conducted before confirming that the conflict has been resolved. With such an approach, one can develop a program that allows human activities to continue without compromising biodiversity. However, in order to ensure that the conflict remains solved, education programs and, if necessary, legislations must be implemented. This is further explained in the following examples.

Example 1− Integrated Pest Management, preventive measures, and community stewardship

Season after season, and year to year, farmers have used large quantities of poisons to control fossorial rodents such as the northern pocket gopher and the Richardson's ground squirrel. However, commonly used strychnine, zinc phosphide and anticoagulants are rarely effective to control these rodent populations (Proulx 1998, 2014), and they significantly impact on wildlife communities by poisoning small mammals and birds feeding on baits, and predators and scavengers feeding on moribund or dead animals (Proulx 2011). One would think that these repeated expensive applications of poison baits, and their poor control performances, would suffice to convince farmers to use alternative methods (Proulx 2014). However, old ways die hard!

Farmers should not initiate pocket gopher or ground squirrel control programs as soon as they confirm the presence of these rodents in their fields. A concentration of rodents at the edge of a field or in small well-delineated areas of a field does not justify poisoning the whole field, as has been done in the past with the use of the burrow builder to kill northern pocket gophers with poison baits (Proulx 2002a). Once farmers have identified the presence of fossorial rodents in their fields, they need to seek support from agricultural offices and wildlife specialists, and learn more about the species to implement an effective Integrated Pest Management Program (Figure 15). The earlier the discovery of pocket gophers and ground squirrels, the easier it is to control the species. No control method will be successful during population outbreaks (Witmer and Proulx 2010). Removing small pockets of populations in spring is much more effective than trying to control well established populations across fields. Farmers must initiate the IPM early in the rodent colonization to remove most of the breeders before the birth of litters, and eliminate emigration, usually associated with the dispersal of young-of-the year animals (Proulx 2014). They must select control methods that are humane, species-selective, safe to humans, socially acceptable, and affordable.

Farmers must know that poisons and gas do not work well with these rodents (Proulx 2014). In the case of the northern pocket gopher, the border control strategy (with perimeter traplines) is the most effective approach to control pocket gophers without impacting on sympatric wildlife species, namely long-tailed weasels (Proulx 1997). In the case of the Richardson's ground squirrel, aluminum phosphide pellets allow one to achieve high control levels with relatively less impact on other wildlife species because poisoning is limited to the burrow system (Proulx *et al.* 2011). Shooting is highly selective and can be used to control ground squirrels. However, as rodent numbers decrease, more effort is required to shoot remaining animals. Shooters must therefore be persistent in order to remove all animals; otherwise, the surviving animals will recolonize the area through reproduction. Farmers may consider amalgamating 2 different methods. For example, shooting could be followed by trapping, or a treatment with aluminum phosphide.

For both species, however, non-lethal alternatives exist. In the case of the northern pocket gopher, avoiding large continuous hayfields (particularly alfalfa *Medicago* spp.), and interspersing them with crops that are not attractive to pocket gophers, helps avoid large pocket gopher infestations (Proulx, unpublished data). In the case of ground squirrels, keeping grasslands ≥15-cm high significantly impacts on the success of ground squirrels to colonize fields (Proulx *et al.* 2012). For both species, long-tailed weasels, American badgers, red fox and birds of prey are effective predators which can keep small rodent populations in check. Farmers should support the establishment of a diversified predator community in their fields and maintain shelterbelts and other refuge areas such as rock piles (Figure 16). The IPM concept is not new (e.g., Stern *et al.* 1959; Lewis *et al.* 1997) but it has not been properly implemented in the control of fossorial rodents and the conservation of small carnivores in Canadian agricultural land. An IPM program must be perceived as a preventive approach to avoid population outbreaks. It is therefore necessary to continuously monitor populations at landscape level, and determine how and when an IPM program needs to be implemented to avoid population outbreaks.

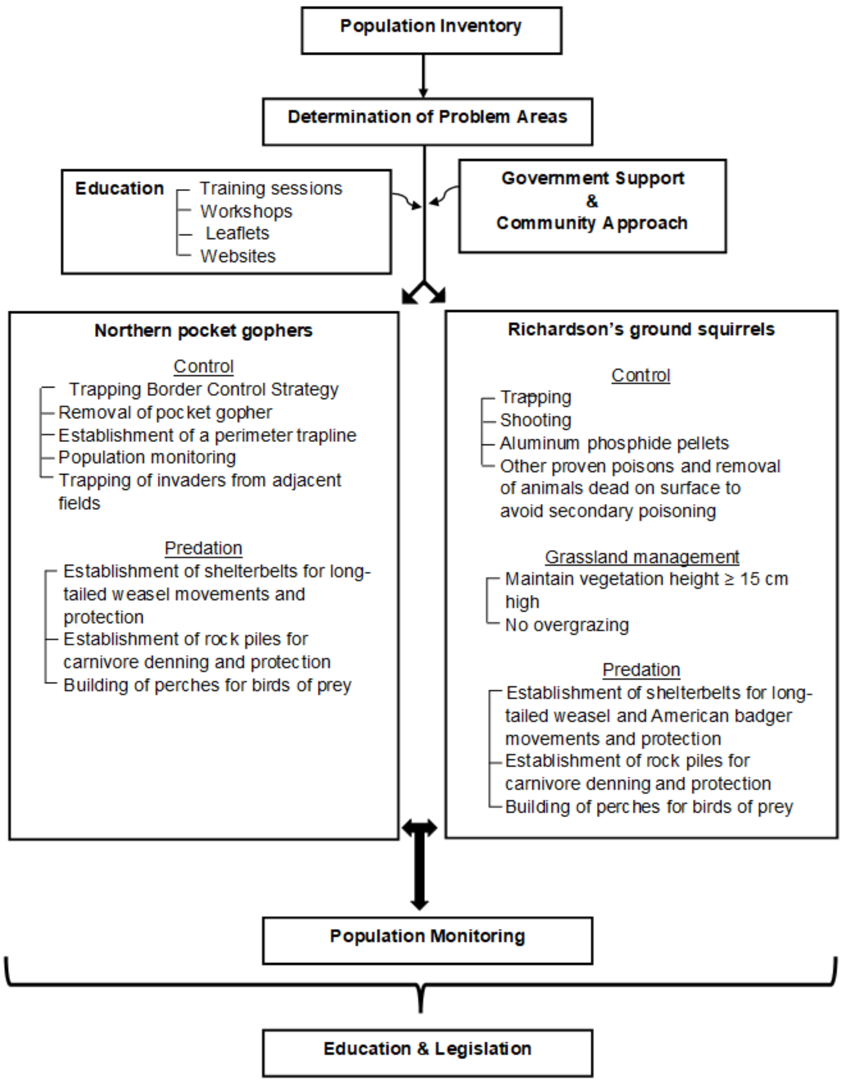

Figure 15. Stepwise approach to assess and resolve human-fossorial rodent conflicts (Proulx 2021a).

The implementation of an IPM to control fossorial rodents, and other "pest" species, should be done with a stewardship community program where neighbours come together to implement the control methods. For example, Proulx (2002b) explained how to implement the border control strategy for northern pocket gophers in individual fields. Basically, the method consists of trapping pocket gophers from the centre of a field toward its edges. During the trapping period, farmers must ensure that no recolonization occurs at the centre of the field. When the pocket gophers have been trapped out, a ≥20-m-wide trapline is established along the edges of the field by monitoring traps set in old burrow systems. These traps intercept immigrant pocket gophers. This technique can be used by farmers to remove pocket gophers in their own fields, and reduce the number of potential immigrants invading their neighbours' fields. On the other hand, the border control strategy can be implemented at the centre of a section (260 ha) instead of a field, and all quarter-section owners can join forces to control rodents from the centre to the edge of the section. The same community stewardship approach can be implemented by a series of neighbouring farmers to control ground squirrels. All of them can establish a rotation system where cattle are moved from one quarter section to another to avoid overgrazing. If all the farmers of a section (or larger area) do this, they would all work at maintaining ≥15-cm-high vegetation, which is detrimental to ground squirrels because they cannot monitor the presence of predators near their burrow systems and fall prey to weasels, badgers and foxes.

Figure 16. Small carnivores, which feed on fossorial rodents, establish their den and seek refuge in rock piles in agricultural lands.

Example 2– Predator control

In the last decades, predator control has become a regretful habit among academics (such as Hervieux *et al.* 2005) and wildlife agencies (Bergstrom *et al.* 2014). Independently of the objective of the terrestrial mammal predator killing program, i.e., for human health, or to save native and endangered species, successful programs should be based on scientific evidence and a proper understanding of ultimate (the 'real' reason causing the observed result) and proximate (event which is closest to, or immediately responsible for causing, some observed result) mortality factors for a wildlife population, or the causative agents responsible for the spread of a disease (Proulx 2018b). Terrestrial mammal predator killing programs are successful when they focus on the main factor that is responsible for the problematic situation; they focus on problem animals; and they are developed with an understanding of the ecology and behaviour of the predators (Proulx 2018b). In my experience, these conditions are rarely met by wildlife agencies and academics aiming to please interest groups and politicians. Establishing a bounty program to cull coyotes (Proulx and Rodtka 2015), or a wolf poisoning program to allegedly save caribou (e.g., Hervieux *et al.* 2005), does not properly address the human–wildlife conflicts or any of the conditions listed above.

Furthermore, social perception and stakeholders' attitude towards mesocarnivores may not be representative of actual species abundance (Suárez de Tangil 2023). Also, people may not have the ability to identify carnivore species, and there is a significant need to increase their knowledge.

Proulx (2018b) developed a stepwise human–predator conflict resolution strategy that included some of the recommendations made by Leopold and Chamberlain (2002) and Dubois *et al.* (2017). In this strategy, a predator culling program cannot be based on prejudice, perceived problems based on anecdotal reports, or political requests to accommodate the activities of some lobbyist group or the interests of industry (Figure 17). Once it has been ascertained that a predator management program is required, it is important to determine if there are non-lethal alternatives to killing animals. Such programs may be cheaper and more effective than killing predators, and they impact less seriously on wildlife communities (Proulx 2018b). The selection of killing programs should rigorously discriminate between techniques. Killing methods should be humane, highly selective, efficient, and socially acceptable (Figure 17). Public attitudes toward predators have changed drastically in recent years (Musiani and Paquet 2004), and the public is increasingly skeptical of the methods employed in control actions (Slagle *et al.* 2017).

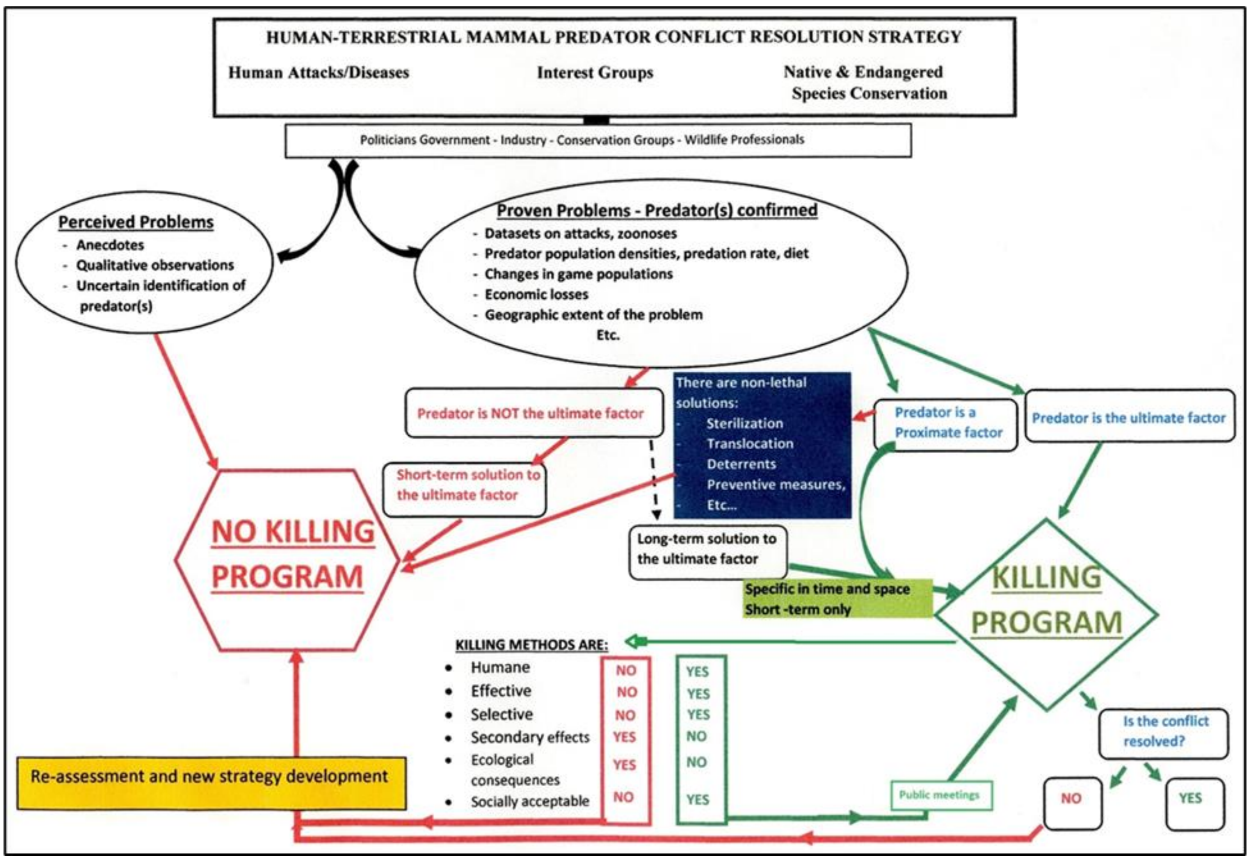

Figure 17. Stepwise strategy to resolve human-predator conflicts (Proulx 2018b).

The implementation of this stepwise strategy recognizes the fact that predators should not be killed without a good reason, and a proper understanding of their ecological role in wildlife communities. Villeneuve and Proulx (2024) showed that the reestablishment of grey wolves through reintroductions and recolonizations in North America, resulted in a series of trophic cascades where the impact of herbivores on vegetation growth was kept under control; sympatric large carnivores shifted their diet; the impact of mesocarnivores on the survival of pronghorn fawns was reduced; beavers and songbirds re-established themselves; scavengers benefited from a larger supply of food items; diseased animals were culled; and invasive species were subject to some depredation. All carnivore species likely contribute similar ecological advantages to wildlife communities. When predators are culled, all these ecological advantages may be weakened or even lost. Therefore, if predators must be culled, the promoters of the culling program must provide robust justification and factual evidence (van Eeden *et al.* 2017). There is a need to adopt a more holistic and ecosystem-based management approach at the expense of lethal programs (Bergstrom *et al.* 2104).

Managing conflicts between large carnivores and livestock is a politically charged activity of all wildlife agencies (van Eeden *et al.* 2017). When lethal control is judged necessary to resolve specific predation problems, the selective removal of problem animals is more effective than any bounty program (Jaeger *et al.* 2001; Bradley *et al.* 2015). However, producers can use non-lethal methods to help prevent or minimize predation problems. Although the efficacy of some techniques is questionable, and no one method will always work in all situations (Bangs and Shivik 2001), livestock guarding dogs are usually effective in preventing predation by wild canids in pastures (Treves *et al.* 2016; van Eeden *et al.* 2017). Any dead, diseased or dying animal left unguarded on ranches is an attractant for scavengers and easily identified as vulnerable prey by predators. Hauling away, burying or burning livestock carcasses rather than leaving them in the field to decay reduces the chances of attracting coyotes and wolves (Defenders of Wildlife 2016; Wolf Awareness 2017). The afterbirth from calving can also be a powerful attractant for coyotes and wolves; this should be taken into account when planning the timing and location of calving activities (Proulx and Parr 2018). Finally, hiring range riders specifically for the calving and grazing seasons to patrol the areas frequently, particularly at dawn and dusk, can considerably minimize conflicts with wild canids (Wolf Awareness 2017; Proulx and Parr 2018).

Animal welfare and alternatives to current technologies

The welfare of individuals and the ethical treatment of animals are part of conservation biology (Paquet and Darimont 2010; Brook *et al.* 2015). In the past, many lethal sport activities and wildlife management programs have been criticized by the scientific community and the public because of concerns related to animal welfare (Proulx 2022a).

As I previously pointed out, few subjects have generated as much emotions as mammal (furbearer) trapping. The major issue with trapping is the questioning about the necessity of trapping and the controversy surrounding the welfare of trapped animals. This must definitely be resolved through the use of improved trapping standards (Proulx *et al.* 2020, 2022) that would be representative of state-of-the-art trapping technology, and the implementation of effective and ethical research and management programs (Proulx 2018c).

Proulx (2022) developed a decision process to justify mammal trapping (Figure 18), which could be applied to any wildlife management program involving the capture and handling of animals. Proulx (2022a) classified trapping activities into 5 categories: sustenance, research, human-wildlife conflict, fur trapping, and wildlife management (Figure 18). Fur trapping and similar activities would be justifiable if: 1) they are selective; 2) they do not impact on SAR; and 3) they use only technology that meets the highest standards of animal welfare (Proulx *et al.* 2022a). One major endpoint in Figure 18 is the implementation of the state-of-the art technology. In order to meet this ultimate objective, governments and wildlife agencies must implement proper procedures to assess and certify traps, and implement regulations that are meant to ensure that the best humane trapping systems are being used in the field. Unfortunately, today's assessment procedures are inadequate (Proulx *et al.* 2020), and regulations are not implemented (Feldstein and Proulx 2022). Furthermore, there is a need to educate trappers and researchers about what humane trapping involves. Until now, organizations such as the Fur Institute of Canada (2021) and the US Wildlife

Agencies (White *et al.* 2021) have focused their attention on trapping devices. In reality, unless assessments are focused on trapping systems, which include the trap, bait, and set, no humane trapping certification can happen. This is because a trap model can be set in many different ways (Proulx 2022b). Traps must be tested in specific trapping systems, and if they pass the acceptation criteria, these traps must be used in the same systems in order to be humane (Proulx *et al.* 2022a). Currently, trap testing and certification employs inadequate evaluation protocols and implementation procedures.

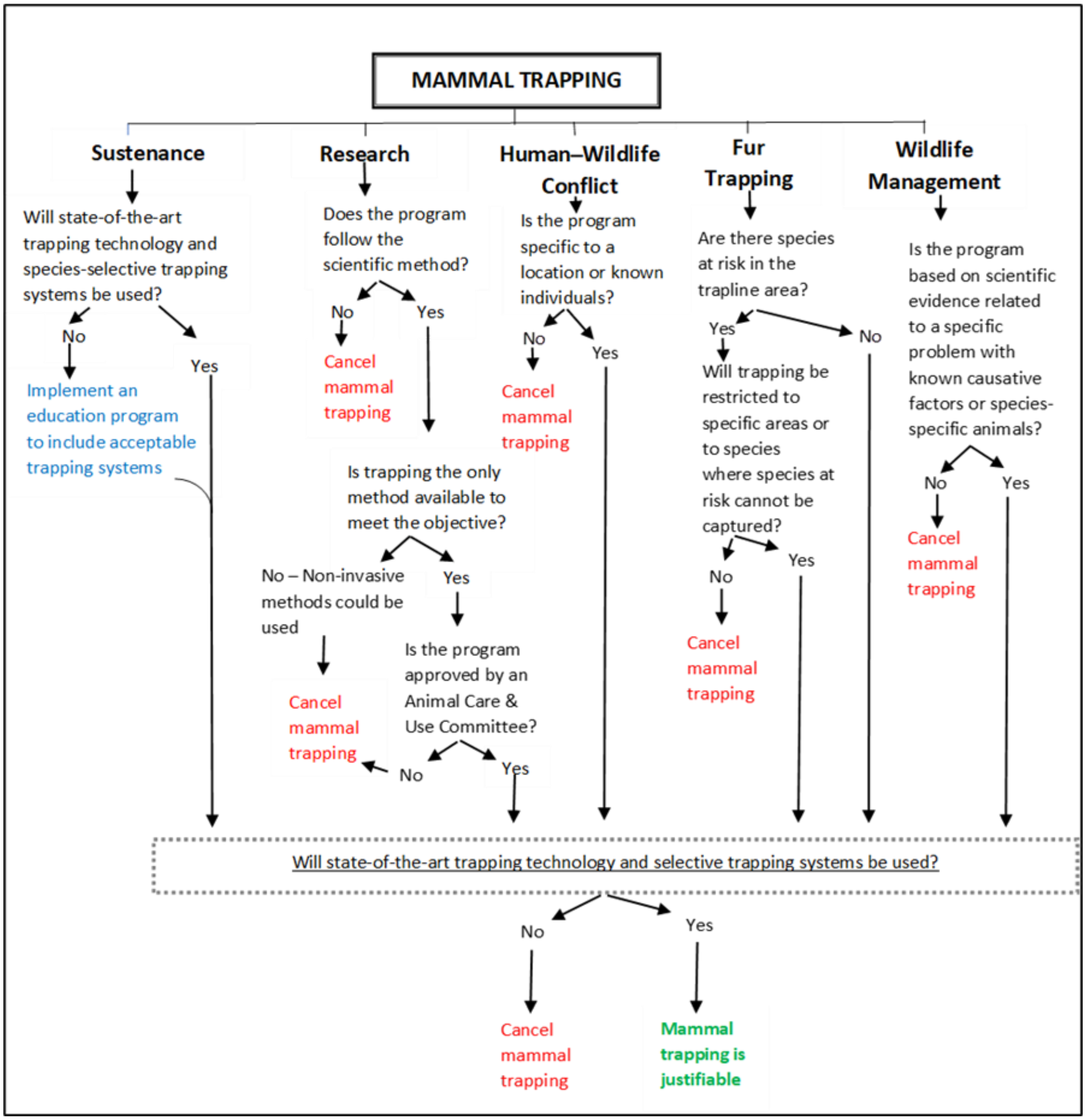

Figure 18. Decision process that may be used to justify the use of mammal trapping and other similar activities (Proulx 2022a).

Researchers and managers should implement Russell and Burch's (1959) *3R* principles – *Replace, Reduce, Refine* – and limit the pain and distress that animals are exposed to in trapping (Zemanova 2020). As I pointed out in the above predator control strategy, when actions are required to address a predator issue, it is important to determine if there are non-lethal alternatives to killing animals (Figure 17). There are many examples of alternative technologies to handling and trapping to study wildlife. Signs such as animal tracks, scats and food remnants, dens and latrines may be used to study species habitats and distributions. This information can be further documented with observations from camera traps, questionnaire surveys, and the collection of roadkills (Proulx 2022a).

Protection

Habitat protection and connectivity corridors

One major issue in wildlife conservation and management relates to habitat loss through destruction, deterioration, and fragmentation. Habitat loss alone accounts for the greatest declines in species abundance and presence (Dykstra 2004). The spatial effects of habitat loss refer to changes in the configuration and connectivity of landscapes, such as the size, number and isolation of habitat fragments. Also, as habitat fragments become more isolated in the landscape, colonization is increasingly unlikely (e.g., Proulx *et al.* 2018). Movement by individuals therefore determines the scale at which they respond to patchiness and spatial heterogeneity (Edenius and Sjöberg 1997; Fahrig and Paloheimo 1988) and, as a result, the amount of habitat required to maintain populations above the extinction threshold increases with dispersal habitat removal (Dytham 1995).

All species have a "minimum suitable habitat" requirement that they require for persistence, and to maintain a minimum viable population. The minimum amount of habitat that needs to be preserved to allow persistence of all species in a region is often unknown, but is likely variable because the reproduction and dispersal attributes of the most sensitive species vary among regions (Fahrig 2001). Species with low reproductive potential, high dispersal rates, and low survival rates require very large amounts of habitat for persistence (Banci and Proulx 1999; Fahrig 2001). At landscape level, protecting approximately 60–65% of habitats appears to be a conservative approach to ensure the persistence of sensitive species in grasslands and species requiring structural complexity in mature and old-growth forests (Bascompte and Rodriguez 2001; Weir and Corbould 2008; Fortin *et al.* 2017; Johnson *et al.* 2019; Proulx and Aubry 2020).

Maintaining large habitat patches at landscape level can be achieved through the establishment of provincial, state and national parks. The leadership and guidance of Indigenous peoples are critical to achieve Canada's domestic and international biodiversity goals including conserving at least 25 % of Canada's lands and oceans by the end of 2025, and creating healthier habitats for SAR. In the spirit of reconciliation, the Government of Canada partners with First Nations, Inuit and Métis to plan and establish several protected areas with Indigenous leadership and to help support employment positions through initiatives like Indigenous Guardians (Indigenous Circle of Experts 2020; Government of Canada 2022c). Habitat conservation could be further realized through the establishment of refuges where species are protected from hunting and trapping (Proulx and Aubry 2020), and urban and sub-urban recreational areas/reserves (Badry *et al.* 1997; Proulx *et al.* 2018). Since 1962, Nature Conservancy Canada has helped to protect more than 15 million ha across the country (see https://www.natureconservancy.ca/en/what-we-do/?_ga=2.129605644. 1449276732.1680559563-356954851.1680559562). Since 1971, The Nature Trust of BC, along with various partners, has acquired more than 500 parcels of land in British Columbia for vulnerable wildlife and plants (see https://www.naturetrust.bc.ca/conserving-land). Organizations such as Wildlife Habitat Canada provides funds that support habitat restoration, enhancement and protection all over Canada since 1985 (see https://whc.org/what-we-do/).

Canada's largest parks tend to be situated in the north where species diversity is relatively low and there are far fewer competing agricultural land uses (Kerr and Cihlar 2004). In southern Canada, where endangered species are numerous, protected areas are scarce, and land use conflicts limit the potential reserve network expansion, habitat maintenance must rely on cooperation with private landowners (Kerr and Cihlar 2004). While there is a need for governments to increase incentives with adequate monetary compensation to secure private landowner participation in land conservation (Kamal *et al.* 2015; Schuster *et al.* 2018) and acquire large tracts of land (van Kooten and Schmitz 1992), various programs (see Birds Canada 2020), many of them involving voluntary stewardship, have been developed:

- Since 1938, Ducks Unlimited Canada has completed more than 11,890 projects and conserved, restored, and positively influenced more than 66 million ha of habitat by conserving wetlands and other natural habitats across North America (see https://www.ducks.ca/).

- In 1996, the Saskatchewan Wetland Conservation Corporation (SWCC; now Saskatchewan Watershed Authority) recognized the need to conserve habitats and subsequently focused its activities on voluntary habitat stewardship programs with private landowners. The primary objectives are to (1) discourage breaking of native prairie, (2) provide technical assistance to the producers if they are contemplating changes in management, and (3) contact new landowners to encourage them to conserve the native prairie. SWCC's Native Prairie Stewardship Program is focused on private individuals that own and/or manage native prairie. Since 1996, over 750 private landowners have participated in the program through Voluntary Stewardship Agreements. The Voluntary Stewardship Agreement is a verbal agreement whereby the producer agrees to maintain their native prairie to the best of their ability and to notify SWCC of major changes in management or change in ownership. SWCC's Native Prairie Stewardship Program comprises habitat enhancement, restoration, and securement. While the program is delivered throughout the grassland region of Saskatchewan, current emphasis is placed on key landscapes under the North American Waterfowl Management Plan (Davis *et al.* 2005).

- The Operation Burrowing Owl (OBO) program is a volunteer initiative in southern Saskatchewan that was established through public awareness and education (Warnock and Skeel 2004). In the OBO program, landowners with nesting burrowing owls agree to maintain critical grassland habitat by not cultivating their land and to continue to protect the habitat if owls do not return to nest (Hjertaas 1997, Skeel *et al.* 2001).

- Environment and Climate Change Canada (2017) developed an action plan for multiple SAR in southwestern Saskatchewan through cost-effective measures and collaboration with land owners and other land users.

- Nature Saskatchewan partners with Saskatchewan landowners to deliver a Habitat Enhancement Program that was initiated in 2000. The program involves a 50:50 cost share to enhance habitat for the endangered burrowing owl, the threatened Sprague's pipit (*Anthus spragueii*), and/or the endangered piping plover (*Charadrius melodus*)

- Since 2006, ALUS, originally an acronym for Alternative Land Use Services, is a charitable organization with an innovative community-developed and farmer-delivered program that produces, enhances and maintains ecosystem services on agricultural lands (see https://alus.ca/our-stories/). Projects such as wetland restoration and enhancement, riparian buffers, shelterbelts, afforestation and native prairie grass restoration provide cleaner water and air, habitat, carbon sequestration and climate resiliency.

Protecting large tracts of land is undoubtedly the best approach to protect SAR and biodiversity. However, acquiring such areas is difficult and expensive, and large expanses no longer exist in agricultural regions of southern Canada. Establishing a network of corridors may be the only way to expand the range of one or many species by connecting sites with ecological potential. Some of these sites may be valuable but isolated from other valuable areas. Other sites may not be ideal but they could be restored or modified to accommodate animal movements and temporary use. I illustrate this in Figure 19 where a connectivity corridor could be established within and between Alberta and Saskatchewan to accommodate animal movements, expand the distribution and size of populations, allow for local adaptation, and maintain connectivity and gene flow across landscapes as recommended by Montgelard *et al.* (2014). In this example, a single linear corridor crosses various regions with known occupancy by SAR. However, in some areas, in order to accommodate animal movements, the corridor could be split into different branches that reconnect further away. In some areas, because of a barrier caused by a road or a highway, an over- or under-pass may be added to connect 2 segments of the corridor. Once a route has been identified, different approaches may be considered to connect valuable habitats and promote gene flow. Although it is unknown whether the corridor would be used by all SAR, and biodiversity would be preserved over large temporal and spatial scales, the establishment of this corridor would be a positive action towards the conservation of an effective habitat matrix.

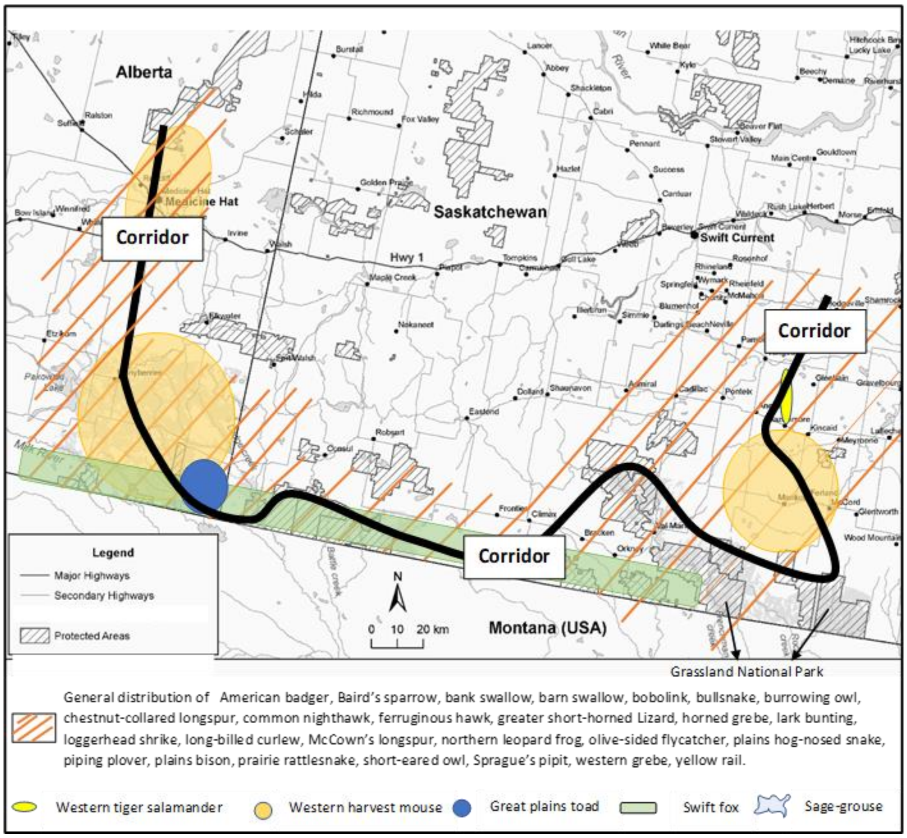

Figure 19. Example of a multi-species at risk connectivity corridor across agricultural landscapes in the Canadian Prairies. Distributions of SAR based on COSEWIC status reports (Government of Canada 2022d) and Proulx and Proulx (2012).

The establishment of the corridor would not require expensive assessments to determine critical habitats, or convoluted procedures to address financial and political constraints that could be imposed by governments. The creation of such a corridor would simply need the accord of landowners to participate in the establishment of connectivity between pastures and hayfields, and to not convert these habitats into annual crops without ensuring the existence of alternative routes. Some of these lands have already been incorporated and even restored in voluntary conservation programs listed above. The route and supervision of the corridor could be done by local naturalist groups and non-profit organizations which all know well the lands with greater potential for wildlife, and operational funds could be secured through different environmental groups and conservation program initiatives to restore or enhance wildlife habitat. Knowing that dedicated human and financial resources for connectivity conservation are low at government level

(Lemieux *et al.* 2021), the creation of this corridor could be a valuable approach to address habitat loss and discontinuity experienced by SAR.

The concept of corridor connectivity is not new, and it has been employed for the conservation of many taxa around the world (Bennett 2003). Corridors may be developed using modeling (e.g., Alexander *et al.* 2016; Bauduin *et al.* 2020), field datasets (Proulx 2015), or reviews of species ecological needs (Proulx and Aubry 2020). Corridors may be identified within a same landscape, or between landscapes as in the National Huemul Corridor (Mowbray 2023) or even countries as in the Yellowstone to the Yukon Corridor (The Yellowstone to Yukon Conservation Initiative 1998). Enhancing landscape-level habitat connectivity is a critical component of climate change adaptive conservation planning (Lemieux *et al.* 2021).

Indicator species to identify species-at-risk habitats

Inventorying habitats and determining suitable ones for SAR may be an expensive and long project, particularly when the species have a few animals scattered across landscapes. Ruggiero *et al.* (1988) recommended using indicator species, i.e., organisms whose presence, absence or abundance reflects a specific environmental condition, such as the spotted owl (*Strix occidentalis*), American marten (*Martes americana*), and pileated woodpeckers (*Dryocopus pileatus*) to identify habitats for mature and old-growth forests with specific canopy and ground structural characteristics including snags and coarse woody debris. Likewise, Proulx (2005a) selected the American marten as a valuable coarse filter indicator species in central British Columbia to identify habitats of SAR with similar habitat requirements. He found that the American marten habitats corresponded to late successional stands with structural complexity that met the habitat requirements of a series of fine filter SAR such as mountain caribou, fisher (*Pekania pennanti*), and wolverine (Figure 20). Thereafter, the protection of habitats of fine filter species inhabiting late-successional stages was based on the determination of American marten habitats.

Perseverance of populations

The conservation and management of wildlife populations depends on a good understanding of the life history and ecology of species, i.e., the reproductive and physical conditions of the animals, the age and sex ratios of the populations, the movements and behaviour of young and mature individuals, and the resiliency of populations to losses due to biotic and abiotic factors, including human activities (e.g., Stirling 1989; Franzmann and Schwartz 1997; Banci and Proulx 1999; Mech and Boitani 2003; Baldasarre and Bolen 2006; Aubry *et al.* 2012; Proulx and Do Linh San 2016; Boal and Dykstra 2018). However, the conservation and management of populations cannot be achieved without the conservation and management of habitats, as Proulx and Aubry (2020) demonstrated for the *Martes* Complex (Figure 21).

Proulx and Aubry's (2020) strategies were developed for American marten, fisher, wolverine and relatives. Habitat management is oriented toward the retention of properly connected late-successional stands (Figure 21). For early-seral species, focus would be on the maintenance of habitats and corridors across grasslands, marshes, sand dunes, etc. However, the study of population dynamics (e.g., Proulx and Gilbert 1983; Fortin and Cantin 1994; Gaillard *et al.* 1998), and factors impacting on the perseverance of species, would remain the same, independent of the habitats preferred by wildlife species. An array of strategies can be used to maintain the structure and dynamics of populations, and under some circumstances, it may be necessary to stop all harvests to allow populations to increase in number (Figure 21), as was successfully done for fishers in a portion of Québec (Garant and Crête 1997) and for sea otters along the Pacific Coast (McLeish 2018); limit trophy hunting (Douhard *et al.* 2016); or increase harvests to protect habitat and wildlife communities (McShea 2012). Ultimately, it may be necessary to implement translocations to ensure the perseverance of populations (IUCN 1987, 2013b), or to re-establish ecological functions within ecosystems (Villeneuve and Proulx 2024).

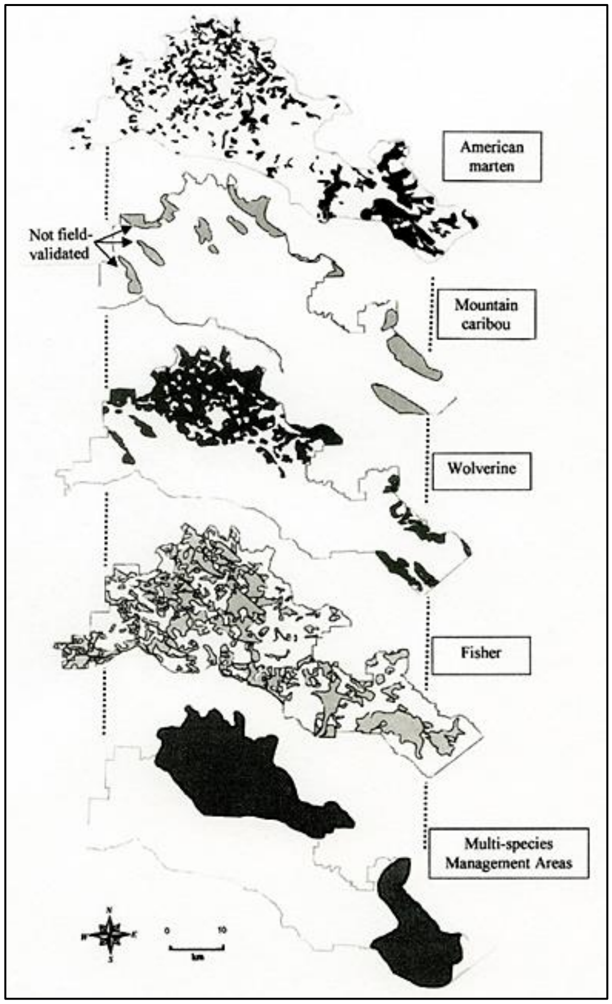

Figure 20. Superimposition of winter habitats used by the American marten, *Martes americana*, the wolverine, *Gulo gulo*, and the fisher, *Pekania pennanti*, in a central interior British Columbia landscape, and delineation of multi-species management areas (Proulx 2005a),

Translocations are not without downsides (Chipman *et al.* 2008; Mengak 2018), and they are a high-cost endeavor with a history of failures. The most reported-upon problems had to do with animal behaviour, followed by monitoring difficulties, lack of funding, quality of release habitat, lack of baseline knowledge and lack of public support (Berger-Tal *et al.* 2020). Weeks *et al.* (2011) and Furlan *et al.* (2019) developed a decision process for determining whether to proceed or assess risk in translocations. Batson *et al.* (2015) proposed a collection of tactics to support the IUCN Guidelines for wildlife translocations and improve the quality of applied methods. Facka and Powell (2024) recommended that translocations be designed *a priori* and evaluated based on diverse goals that include population viability, ecosystem integrity, ecological services, scientific advancement, stakeholder goals and other appropriate goals. They also recommended that translocation projects formally incorporate monitoring and report how negative outcomes relate to overall project success.

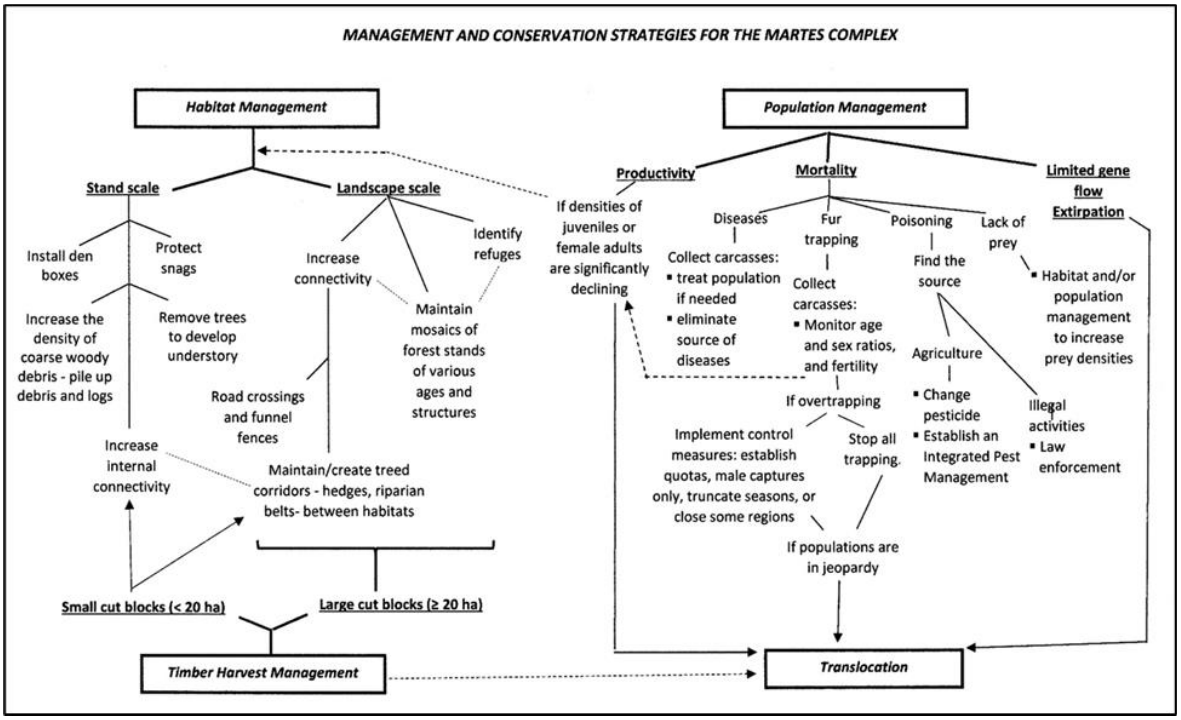

Figure 21. Strategies for the management and conservation of populations and habitats of species in the *Martes* Complex that can be adapted to all wildlife species (Proulx and Aubry 2020).

Examples of successful translocations have been reported by Proulx and Aubry (2020) who listed a series of translocations programs involving species of the *Martes* Complex to: 1) re-establish a population within its historical range; 2) augment a population (i.e., movement of individuals into an extant population of conspecifics) to improve reproductive success or increase genetic variation; and 3) mitigate the effects of adverse environmental changes on populations. Translocation of grizzly bears adults (Servheen *et al.* 1995), and the rescue of orphaned cubs for their eventual translocation in the wild years later (Treptow 2009; Cacaci 2010), may be used to re-establish depleted populations. Coppola *et al.* (2020) explained how translocations in landscapes with proper connectivity among habitats can be used to restore northern bobwhite (*Colinus virginianus*) populations. Germano and Bishop (2008) and Zippel *et al.* (2011) discussed successful translocations for amphibians and reptiles.

Prevention

Habitat loss

When it comes to habitat loss and SAR, further degradation of the environment can be prevented by monitoring the state of the habitats at regional level. In boreal forests, at least 65% of landscapes should provide wildlife with proper structural complexity. Late-seral stands should be properly interspersed with mid- and early-seral stages (Proulx and Joyal 1981; Proulx and Aubry 2020). Aquatic habitats, particularly marshes, should provide wildlife with adequate vegetation beds interspersed with water (Proulx and Gilbert 1983). If the proportion of habitats required to maintain complex wildlife communities fall below 65% of the landscape, forestry and mining activities need to be suspended and a plan of action is required to create new habitat for every parcel of land disturbed by industry exploiting natural resources.

Monitoring and pollution

The development of monitoring programs is the best prevention against an increase in gas emissions. Knowing the exact location and number of spills results in action to stop these spills and force industry to clean them up and restore wildlife habitats. Such monitoring must be implemented with serious enforcement of the laws for polluters. The Government of Canada has generated programs to reduce gas emissions in various sectors of the economy (Government of Canada 2022e), support the deployment of infrastructure for alternative transportation fuels (Government of Canada 2023b), improve community access to clean energy funding and resources (Government of Canada 2023c), and more. Governmental initiatives are far from being perfect, and they certainly impact on the socio-economical well-being of communities. However, altogether, Canada's commitments will likely reduce national contribution to emissions and climate deterioration, and reduce the exposure of wildlife populations and habitats to oil, gas, and coal emissions. Pollution can be prevented with more conscientious energy boards and greater efforts to reduce our dependency on fossil fuels. Ultimately, to prevent further deterioration of air, water and land, fossil fuels must be reduced and replaced with greener energy. Funding for the development and implementation of green energy must be enhanced at the expense of oil and gas supporting funds. Prevention also encompasses the development of educational programs – the public needs to know the truth behind fossil fuel industry spills and ineffective programs to allegedly clean sites polluted by oil and saline spills.

Pesticides must be assessed by parties independent from industry and political influence. Only such assessments will ensure that products sold on the market will not jeopardize wildlife and its habitats, and the health of Canadians. In order to maintain clean air, water, and lands, political will and industrial cooperation are necessary to reduce the impact of pollutants on wildlife conservation. Failing to do so means that some chemicals will persist in the environment even after their ban, as is the case with PCBs.

A thorough assessment of pesticides must be based on their effectiveness in reducing conflict wildlife populations; their selectivity, i.e., they do not endanger other species, particularly those feeding on carcasses on poisoned animals; and their humaneness, i.e., they do not cause prolonged pain and suffering. With a thorough assessment of pesticides, ecological impacts associated with the control of "pest" species will be minimized. Furthermore, when implementing the control of a species with an IPM in stewardship community programs, one can prevent the excessive use of pesticides across the land.

Invasive species

The first step to prevent the establishment of invasive species is detection and mapping of their distribution (e.g., Aschim and Brook 2019). Mapping the locations of invasive species is central to guiding effective management and is essential to determine if control efforts are effective at regulating and limiting, or even reducing, their spatial expansion (Elith and Leathwick 2009). It is therefore necessary to gather relevant data on the species distribution in a specific region as soon as the invasive species has been detected, determine its expansion over time, and identify the control technique that is the most appropriate to eradicate the invasive species without impacting on wildlife communities and ecosystems (e.g., Villeneuve *et al.* 2022; Proulx and Villeneuve 2022). A rapid response by all government levels, naturalist groups and the public is essential to curtail the expansion of invasive species. Preventing the establishment and spread of invasive species requires the use of an effective educational program to inform the public about the presence of the invasive species and its impact on the well-being of their environment, how to effectively control the invasive species, and to cooperate with government agencies to eradicate the species. Insufficient appreciation of socio-political context, non-existent or perfunctory public and community engagement, and unidirectional communications can all foster "destructive" conflict in invasive species management (Crowley *et al.* 2017). For example, shooting >600 horses in an Australian national park was highly criticized by the public and this resulted in a ban of aerial culling (Chapple 2005). It is therefore essential for governments to properly inform the public about the conflict species, the reasons for removing the animals (including ecological and socio-economical reasons), and the most acceptable methods from an efficiency and humaneness point of view.

Preventing the impact of invasive species on the environment is not limited to animals. Controlling or eradicating invasive plants can have a significant impact on vertebrate biodiversity. For example, in a study of Great Lakes coastal marshes, Tozer and MacKenzie (2019) found at sample sites where invasive Phragmites was controlled that species richness of 5 breeding marsh bitterns (e.g., *Botaurus* sp.) and rails (e.g., *Rallus* sp.) of conservation concern increased by 1.1 species, and that total abundance of these species combined increased by 1.8 individuals.

Changes in global climate will, among other impacts, increase temperature, modify the precipitation regime, raise the sea level, and increase extreme climate events. It will stress the native flora and fauna and favour invasive species in aquatic environments (Junk *et al.* 2013) and in forests (Dale *et al.* 2001). Monitoring the occurrence of exotic species, and taking immediate action to remove them is mandatory. This will not be done without the involvement of local naturalist clubs, hikers, nature photographers, hunters and anglers, park wardens, field biologists, and special government-funded investigating teams with dogs trained to find specific invasive species (Haber 1997; Kobilinsky 2023). In the long-term, prevention certainly is cheaper to accomplish than the recovery of habitats and SAR.

Professionalism

Disagreement among professionals exists regarding the best approach to resolve a conservation problem or a human-wildlife conflict. However, a wildlife biologist's primary obligation is to the resource rather than the agency or to the people who pay his or her salary (Peek 1986). Failing to recognize such an obligation could result in the implementation of programs that may please some politicians or lobbyist groups, but will ultimately impact significantly on biodiversity.

We know that agency staff fundamentally lacks independence from government policy (e.g., Hutchings *et al.*1997; Lackey 2009), and this may limit their ability to resist political interference (Greenwald *et al.* 2012). Scientists who work for governmental agencies can face strong 'top-down' pressure from within their organizations (which are inherently hierarchical) to reach particular decisions (Karns *et al.* 2018). Oftentimes, professional biologists have been prevented from doing their jobs by risk-averse middle managers and industry apologists who are more concerned with their next promotion and government-funded research than with implementing real conservation and management programs that will benefit wildlife. Furthermore, people are profoundly affected by their social environment (Baumeister and Finkel 2010), and wildlife professionals may tend to conform to the expectations of their peers (Karns *et al.* 2018). Sensible wildlife conservation and management requires special people who can, when confronted with intimidation from politicians, lobbyist groups, and industry, persevere in the implementation of programs aimed at ensuring the persistence of populations and habitats.

Unfortunately, there is no code of ethics and professionalism in the wildlife profession. However, common sense dictates that a wildlife professional should not be afraid to stand against unjustified predator culling programs or the use of inhumane trapping methods (Proulx 2018a). Professionals involved in wildlife conservation and management must be wildlife biologists who are not afraid to be perceived as being adversarial when dealing with SAR, habitat loss, animal welfare, and management policies. Managers should not be in charge because they are yes-men or they are politically well connected. Managers should be biologists who will implement conservation actions and wildlife management programs, and develop strategic responses and policies, that must be transparent and based on good scientific evidence (Pullin and Knight 2001; Sutherland *et al.* 2004). Anything less than this should be a source of concern (e.g., Montoya Bryan and Brown 2023).

Principles to develop a model for wildlife conservation and management

Proulx *et al.* (2022a) pointed out that industries continuously improve their standards, and manufacturers continually innovate and enhance their products to the benefit of users and the environment. The fact is that these corporations do not have a choice − if they don't do it, they will lose public support. The same is true for the wildlife profession which is faced with changing societal values and needs (e.g., Proulx 2023), and serious wildlife issues such as the ones I presented above. The wildlife profession must continuously innovate and improve their conservation and management programs.

In the following, I set a series of principles which I believe to be essential to develop a model for conservation and management that will ensure the persistence of wildlife populations and habitats, and the welfare for individuals. I focus on Canada, but these principles would hold true for any part of the world.

1 - Wildlife is an integral component of people's environment

Wildlife is an integral component of the environment in which Canadians live (Federal Provincial Wildlife Committee 1983; Wildlife Ministers' Council of Canada 1990). The North American Model for Wildlife Conservation recognized that wildlife resources are a public trust. This principle implies that people are temporary custodians, not the owners, of their wildlife heritage. They are free to enjoy and use wildlife in their country, subject to laws aimed at securing its sustainable enjoyment and use.

2- The cost of conservation and management are borne by all citizens and funds are entirely dedicated to wildlife populations and habitats

Both the Federal Provincial Wildlife Committee (1983) and the Wildlife Ministers' Council of Canada (1990) pointed out that all Canadians should share the costs of conserving wildlife. Those whose actions result in additional costs should bear them.

Conservation costs should be borne by non-consumptive and consumptive users. The management of wildlife should not be paid only by trappers, hunters and anglers. Wildlife is also enjoyed by campers, bird watchers, photographers, hikers, and others – they should all contribute to wildlife funding. All the funding should be dedicated to wildlife conservation and management. The funds should not go into a central account where they would be allocated by governments according to their priorities. Also, the funds should not be used exclusively for game and fish management– they should be used to inventory all wildlife species, assess the status of all species, and ensure the persistence of all wildlife species (namely SAR) and their habitats.

This is an important principle that is often overlooked by industry and governments. For example, oil and gas exploitation abandons wells with oil and water leakages that contaminate soils and ground water, and pollute wildlife habitats. There are roughly 170,000 abandoned wells in Alberta and to date, the government failed to ensure that all these wells be properly reclaimed (Egler 2021; Timoney 2021).

3 - The maintenance of viable wildlife populations always takes precedence over their use by people

Wildlife conservation supersedes all forms of utilization, individual, residential or industrial (Federal Provincial Wildlife Committee 1983; Peek 1986; Wildlife Ministers' Council of Canada 1990). The North American Model has a less comprehensive principle that stipulates that markets for game should be eliminated.

Although wildlife management is a practice used to assess and integrate the needs of wildlife with the social, economic and political interests of people, people's interests should not result in the demise of wildlife populations and habitats, or poor animal welfare. For example, in Alberta, the government wildlife minister's recovery program for woodland caribou is based on a program encompassing predator culling and a maternity pen, a program that would not impact on forestry and oil & gas industries, but will not address the ultimate factor causing the decline of caribou, i.e., habitat loss (Proulx and Powell 2016; Proulx and Brook 2017). Habitats for caribou need to be protected and reconnected to allow for population growth, and this must supersede any industry activity to ensure the recovery of this SAR. Similarly, if a species is overexploited (e.g., Artelle *et al.* 2013, 2014; Mowat *et al.* 2020), hunting and trapping regulations should be changed to ensure the conservation of the resource. On the Pacific Coast, reducing the harvest of the Chinook salmon (*Oncorhynchus tshawytscha*), along with a rebuilding plan to increase salmon numbers, should become a priority for the survival of the Southern Resident killer whale (*Orcinus orca*) (Lacy *et al.*

2017). The scientific literature abounds with examples where wildlife stocks did not take precedence over the use by people. This principle might be the most important precept for wildlife conservation.

4 – Wildlife habitat conservation, restoration, and connectivity always takes precedence over landscape development and use by people

This principle is a corollary to the previous principle that viable natural wildlife populations take precedence over their use by people. Simply, wildlife populations cannot exist without habitats. However, this does not mean that anthropogenic developments cannot occur. One must determine: 1) how developments will impact on the integrity of the habitats and wildlife populations; 2) options at landscape level to retain blocks of land and properly interconnect them to maintain actual wildlife communities and animal movements; and 3) alternative locations for anthropogenic developments that would be less damageable to wildlife habitats.

5– Animal welfare concerns are properly addressed in all consumptive and non-consumptive wildlife use

Any type of wildlife use, lethal or not, should ensure the welfare of animals. This does not imply that hunting, trapping or fishing must end, or that agriculture or forest industries must be stopped. This principle implies that human activities should include state-of-the-art technologies that take into account animal suffering, long-term health issues, behaviour, and security.

Anthropogenic activities that impact on animal welfare are too numerous to be reviewed here. For example, all lead ammunition and fishing gear should be banned because they cause adverse impacts on wildlife, humans, and the environment (Lambertucci 2010; Arnemo *et al.* 2019). Mammal trapping standards need to be updated to be representative of state-of-the-art technology, and trapping systems should not be certified unless they have been thoroughly tested (Proulx *et al.* 2020, 2022a,b,c). Wildlife tourism needs to be better managed to reduce negative welfare impacts on individual animals and on their taxon's conservation status (Higginbottom 2004; Moorhouse *et al.* 2015).

Many of these issues could be resolved with greater cooperation among professionals (Cattet 2013; Proulx 2021b), and wildlife consumptive and non-consumptive recreationists (Grooms *et al.* 2022). Somehow, improving animal welfare is also ensuring that the maintenance of viable natural wildlife populations always takes precedence over their use by people.

6 – Invasion of alien species, and the source of these invasions, are immediately stopped

Invasive species have the potential to compromise the future of wildlife populations through disease, hybridization (due to escapes from farms), and habitat degradation. The development of new markets through semi-domestication of wildlife, e.g., deer and wild pig farms, and the possession of exotic animals for personal enjoyment are a constant danger to endemic fauna and flora and should be terminated.

7 – Wildlife conservation is based on multi-disciplinary consultations

Although wildlife conservation and management programs should be developed and implemented by wildlife biologists, such programs should be the result of consultations with various professionals (veterinary medicine, forestry, geomorphology, sociology, history, archeology, and others), nature-oriented organizations, and user groups (consumptive and non-consumptive). Such consultations could allow wildlife biologists to fine-tune parts of their program and secure the support of many parties.

8 – Wildlife conservation and management are science-based

I previously discussed how wildlife conservation and management issues should be based on science. Meeting political agendas and pleasing lobbyist groups should not be part of wildlife biologists' responsibilities, particularly when it is agreed that the maintenance of viable natural wildlife populations always takes precedence over their use by people.

This principle requires that monitoring programs are in place to properly assess: 1) the status and distribution of all species; 2) the impacts of pollutants, pesticides, urbanization, industrial exploitations, and climate change on wildlife populations and habitats; and 3) the nature and severity of human-wildlife conflicts. The implementation of this principle does not imply that wildlife professionals may not take part in multi-disciplinary management programs. The contributions of various professionals and outdoor enthusiasts must, however, be supported with factual evidence.

9 – Public education, school programs, and community initiatives are essential components of wildlife conservation and management programs

The current world population exceeds 8 billion people. More people translate into greater needs for space and food, and more stress on the environment, wildlife populations and habitats. Climate change, an increase in pollution and pesticides, frequency of human-wildlife conflicts, number of invasive species, zoonoses, and more illegal wildlife trade and poaching are associated with an increasing human population. All this significantly impacts on wildlife conservation and management. Education is the most important tool that needs to be implemented to ensure the future of wildlife. Without education and a global transfer of information to the public and professional worlds, no wildlife model will ever succeed.

Wildlife conservation and management, the ecological needs of populations and habitats, and the future of human-wildlife relationships need to be taught at all levels, and particularly in schools. Programs provided by wildlife organizations, environmental groups, naturalist clubs, and networks of school teachers and wildlife professionals are essential to ensure the future of wildlife. Bergman *et al.* (2022) found that social media can increase pro-conservation behaviours among the public, increase conservation funding, and incite policy changes. Conversely, social media can contribute to species exploitation and illegal trade, cause unprecedented increases in tourism in protected areas, and perpetuate anti-conservation behaviours via misinformation. The use of responsible social media, the denunciation of fake news discrediting scientists' concerns about environmental issues, and a greater involvement of wildlife professionals in community services and committees, are necessary. Factual evidence and critical thinking (Proulx 2004) are important tools for wildlife professionals to acquire public support.

10 – Funding needs to be consistent and apolitical from year to year

In order to meet their conservation and management objectives, wildlife professionals must have access to consistent funding on a yearly basis, without strings attached. To this end, it is best to have a constant minimum sum of money that is sufficient to implement all the principles listed above. Funding should be allocated independently of partisan concerns. In order to ensure a minimum sum on a yearly basis, the amount of money could correspond to either a percentage of the Gross Domestic Product, or a fixed amount that is adjusted annually to the increase in the cost of living, or an excise tax on outdoor recreation activities and equipment. Considering that most people involved in some sort of consumptive and non-consumptive activities, securing the money from governments' revenue would actually be representative of the contributions that individuals could make when enjoying the outdoors.

Conclusion

Let's face it, wildlife conservation and management are in a state of crisis. Current programs are ineffective in stopping the growing list of SAR and the loss of wildlife habitats. Wildlife agencies are working with programs that are often outdated and not scientifically credible − these agencies are choking on their own bureaucracy and fail to deliver adequate solutions to current wildlife issues. The above issues are those that I experienced when working in the field over the last 50 yrs as a wildlife biologist. They are not fanciful observations or the result of an overactive mind.

Similarly, the inadequacy of the North American Model for Wildlife Conservation to address the wildlife issues that I described above is a conclusion based on facts. In the past, the Model was not helpful in reducing the number of SAR, eliminating pollutants and pesticides, and stopping overexploitations associated with trapping and hunting. In contrast, the points to ponder and the ensuing principles that I discussed for the development of a more contemporary and adaptable model of wildlife conservation and management address the issues that I identified. I know that some people will claim that these points to ponder and principles are not realistic, that I do not understand bureaucratic processes, or I oversimply the causes of the problems. However, because I worked with governments and industries as a researcher and manager, and because I hunt, trap, fish, and enjoy other outdoor activities, I believe that my observations and recommendations are appropriate as they are based on scientific evidence, experience, and field expertise. Finally, some people will claim that it is idealistic to expect large sums of funding on a yearly basis to save wildlife populations and habitats, and improve animal welfare. However, these people do not realise that the funds generated by wildlife and outdoor activities amount to billions of dollars on an annual basis (Lloyd-Smith 2022), and funds allocated to wildlife conservation and management actually correspond to an investment that benefits all Canadians. Wildlife has cultural, social, economic, and intrinsic values that justify investing large sums of money in conservation and management programs.

In order to understand the relevance of the solutions that I propose to resolve a series of selected issues, I had to point out the inadequacy of government programs to address the future of species and habitats, and the lack of standards to ensure the well-being of individuals. My critique of wildlife conservation programs is not meant to be an adversarial manuscript; it simply identifies weaknesses in current programs, and recommends different approaches to fix these flaws. For some issues, the fix needs to be extensive and requires a change of attitudes among participants and organizations (e.g., the North American Model for Wildlife Conservation). For some other issues, however, one just has to reassess current programs and update them with new approaches that are more representative of state-of-the-art knowledge (e.g., mammal trapping standards). We cannot change what happened in the past, but we can change what will happen in the future.

One important point to make is that managers should not develop programs with unrealistic objectives. Further, wildlife conservation and management programs should be based on scientific evidence gathered in the field (Proulx 2013), and not be led by computer models with unrealistic or untested assumptions (Laymon and Barrett 1986). Callaghan (2011) and Proulx (2012) deplored the paucity of field-based studies in the development of effective conservation measures. While computer modelling produces publishable results much quicker than working in the field (Noss 1996), there are no substitutes for real datasets on populations and their habitats, predator–prey relationships, physiological constraints, genetics, taxonomy, biogeography, and other subjects related to wildlife conservation and management. Evidence based on real-world observations create field datasets that allow for the testing of hypotheses and the development of convincing practical management programs that can be effectively applied (Proulx 2020). Most importantly, the future of wildlife ultimately depends on dedicated wildlife biologists with high professionalism and ethics, working together to implement effective science-based conservation and management programs.

Acknowledgements

This chapter is the result of years of involvement in research and management programs that I published with the help of knowledgeable and professional co-authors. I would not have been able to write this chapter without the participation of all these professionals at some time in my career. I thank Dr. Geoff Holroyd for our discussions on the management of species at risk in Canada, Amanda Carriere for our exchanges on the establishment of a wildlife corridor for species-at-risk in southern Alberta and Saskatchewan, and Pauline Feldstein for discussing the diverse sections included in this chapter. Finally, I am grateful to Lisa Dahlseide and Dr. Barrie K. Gilbert for their comments on an earlier draft of the manuscript.

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