The Canadian Field-Naturalist

An overview of known species killed during Alberta's Gray Wolf (*Canis lupus*) strychnine program, 2005–2020

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Parr, S. 2023. An overview of known species killed during Alberta's Gray Wolf (*Canis lupus*) strychnine program, 2005–2020. Canadian Field-Naturalist 137(3): 259–266. https://doi.org/10.22621/cfn.v137i3.3213

Abstract

To determine the minimum effect of strychnine baits placed for wolves in winter during a program targetting Gray Wolf (*Canis lupus*) in west-central Alberta from 2005 to 2020, I present a summary of all recorded species killed (n = 522). Fewer wolves (n = 245) were killed compared with non-target animals (n = 277), which included 10 mammal and four bird species. These data provide context on the environmental and ethical impacts of using poison as a component of wildlife management.

Key words: Gray Wolf; *Canis lupus*; wolf; predator; predacide; scavenge; strychnine; non-target kill; non-target species; non-target animal; predator control; secondary poisoning; Alberta

Introduction

Strychnine, a highly toxic compound, was first registered for use as a vertebrate pesticide in Canada in 1928 (PMRA 2005). Its use as a wildlife management tool has since been abandoned in all provinces and territories except Alberta (Health Canada 2022). Alberta maintains two separate use permits for strychnine: registration no. 20410 (155 mg/tablet, minimum 38.6% strychnine), which is authorized for use on Gray Wolf (*Canis lupus*), Coyote (*Canis latrans*), and American Black Bear (*Ursus americanus*); and registration no. 24510 (liquid 35 mg/mL), which is authorized for use on Striped Skunk (*Mephitis mephitis*). Both applications involve the use of bait, which is ingested, to deliver the toxin (Health Canada 2021a, 2022, 2023). Strychnine is considered to be a "predacide" by Health Canada, and I use that term in this paper to describe a toxicant registered in Canada as a product to kill predators. Strychnine remains highly persistent in baits and poisoned carcasses (Eason and Wickstrom 2001).

Strychnine affects the central nervous system; clinical symptoms include frequent periods of severe tetanic seizures, hyperthermia, and extreme agitation and restlessness before death by asphyxiation (Eason and Wickstrom 2001; Khan 2010). Death typically occurs within 1–2 h of the onset of symptoms (Khan 2010), but can take 24 h or more with a low dose (Eason and Wickstrom 2001; Proulx *et al.* 2016a). Strychnine also causes death from secondary poisoning (i.e., relay toxicity) when scavengers ingest a poisoned carcass (Cain *et al.* 1972; USEPA 1980; Allan 1989).

Recently, Harris and Armstrong (2021) provided an overview of experimental Gray Wolf poisoning programs carried out in northern Ontario (1956–1965), which included the use of strychnine, cyanide, and compound 1080. In that synopsis, 10 mammal and nine bird species—which the authors emphasize represents minima—were recorded among the non-target organisms killed, with target mammals (wolves, n = 119) accounting for ~31% of total toxicant kills (n = 384; Harris and Armstrong 2021). In Ontario, the use of poison as a wolf-management tool was disallowed by the early 1980s (Kolenosky 1983) and remains prohibited under Ontario's 1997 *Fish and Wildlife Conservation Act* (Harris and Armstrong 2021).

In March 2020, Health Canada's Pest Management Regulatory Agency (PMRA) announced its decision to cancel and discontinue the use of 2% liquid strychnine for purposes of poisoning Richardson's Ground Squirrel (*Urocitellus richardsonii*; Health Canada 2020). In that application, baits coated with liquid strychnine were placed below ground in squirrel tunnels. Nonetheless, the decision to discontinue use was made because of environmental risks to non-target organisms, including species-at-risk.

I consolidated known kills of non-target species during a wolf-strychnine program in west-central Alberta. I focussed on a wolf population reduction program carried out in Alberta as part of provincial recovery efforts for select herds of federally Endangered

Woodland Caribou (*Rangifer tarandus caribou*; Hervieux *et al.* 2014, but also see Bekoff 2014; Brook *et al.* 2015; and Field *et al.* 2019). In the winter of 2005/2006, Alberta's Ministry of Environment and Sustainable Resource Development (AESRD) initiated an annual winter wolf population reduction program that entailed using strychnine in two Woodland Caribou herd ranges in west-central Alberta, in addition to shooting wolves from aircraft (Hervieux *et al.* 2014). The government-delivered toxicant portion of the program was conducted annually in winter until 2019/2020, inclusive, except for 2009/2010 and 2018/2019.

Data on deaths during the program had not been tabulated to compare recorded deaths among target and non-target species, annually or cumulatively. Also, the number of species impacted had not been tallied. To make the data more comprehensive, meaningful, and publicly available, I compiled the existing records and organized known deaths by species. Little peer-reviewed data exist for non-target kills from strychnine programs that target predators. Thus, it is important to shed light on what is known.

The operation and delivery of the wolf-strychnine program I examined are outlined in Hervieux *et al.* (2014), but see Field *et al.* (2019). Ungulate populations in the area included Woodland Caribou, Moose (*Alces americanus*), Elk (*Cervus elaphus*), White-tailed Deer (*Odocoileus virginianus*), and Mule Deer (*Odocoileus hemionus*; Hervieux *et al.* 2014). Large mammalian carnivores in the area included Gray Wolf, Grizzly Bear (*Ursus arctos*), American Black Bear, Cougar (*Puma concolor*), Canada Lynx (*Lynx canadensis*), Wolverine (*Gulo gulo*), and Coyote (Hervieux *et al.* 2014). Scientists and policymakers consider this area "the most highly disturbed woodland caribou range in Canada" (Government of Alberta 2019b: 30/78; also see Denhoff 2016; Hebblewhite 2017).

My objectives were to determine the number and species of non-target birds and mammals recorded as killed incidentally in the aforementioned strychnine program targetting wolves in west-central Alberta from 2005 to 2020. Although this particular strychnine program was not carried out during 2021 or 2022, the federal authorizing permit (no. 20410), under the authority of Health Canada's PMRA, remains active until 31 December 2024. On expiration of the use permit, Alberta may apply for renewal.

Methods

I reviewed and compiled data on all carcass retrievals associated with the wolf-strychnine program from 2005 to 2020. Data came from a variety of sources, including an annual report by the government of Alberta (AESRD 2012), supplementary material from a scientific publication (Hervieux *et al.* 2014), AESRD records obtained through Alberta's freedom of information and protection of privacy process (Government of Alberta 2018, 2019a,b, 2020), Health Canada pesticide incident reports (Health Canada 2013, 2018), and direct communication with the program lead (D. Hervieux).

Records were grouped into mammal and bird categories, and the number of kills was tallied by species. I compared the number of intended kills (wolves) with the number of unintended, non-target kills by strychnine. Where multiple records for the same year showed discrepancies in the data, I used the higher number of toxicant deaths reported and noted the inconsistency. Hervieux *et al.* (2014) describe an average of 15 to 20 strychnine bait stations active during mid to late winters from 2005/2006 to 2011/2012, excluding 2009/2010, for a total of 5709 bait-site days. Although this information was not available beyond 2012, records indicate that from 2012 to 2020 the Woodland Caribou Recovery Program used a total of 8433 strychnine tablets (155 mg/tablet), ranging from 40 tablets in 2016 to 1842 tablets in 2013 (PMRA 2020a).

Results

Overall, strychnine killed fewer wolves (n = 245) than non-target animals (n = 277; Table 1). Recorded deaths of non-target animals exceeded those of the target species (wolves) during nine of the 13 winters in which strychnine was used (Figure 1).

Mortalities were documented for 10 mammal and four bird species (Table 1) including: Bald Eagle (*Haliaeetus leucocephalus*), Canada Jay (*Perisoreus canadensis*), Canada Lynx, Coyote, Domestic Dog (*Canis familiaris*), Fisher (*Pekania pennanti*), Red Fox (*Vulpes vulpes*), Golden Eagle (*Aquila chrysaetos*), Grizzly Bear, Mink (*Mustela vison*), Pine Marten (*Martes martes*), Raven (*Corvus corax*), Striped Skunk, and weasel (*Mustela* sp.).

Discussion

The data presented here should be regarded as the minimum number of kills. Additional kills were likely undocumented and, thus, underreported. For instance, animals wandering away from a bait site with bait in their mouth or a poisoned animal that moves into forest cover before dying (Figure 2b), can preclude carcass detection and retrieval. Scavengers may also consume (Figure 2b) or carry off/translocate a poisoned carcass or part(s) of it. In addition to contributing to undocumented kills, such circumstances can also further distribute strychnine to unknown areas, thereby increasing the likelihood of secondary poisoning and

TABLE 1. Mammals and birds killed by strychnine during west-central Alberta's winter wolf reduction program, by year.

	Year of strychnine program (2005/2006 to 2019/2020)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total (%)
Mammals																
Gray Wolf (*Canis lupus*)	28	19	28	16	0	34	29	27	23	16	0	10	8	0	7	245 (46.9)
Coyote (*Canis latrans*)	6	3	7	9	0	6	5	4	1	1	1	3	8	0	2	56 (10.7)
Red Fox (*Vulpes vulpes*)	0	8	9	6	0	7	1	1	8	3	0	1	0	0	0	44 (8.4)
Domestic Dog (*Canis familiaris*)	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4 (0.8)
Canada Lynx (*Lynx canadensis*)	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	4 (0.8)
Marten (*Martes martes*)	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4 (0.8)
Fisher (*Pekania pennanti*)	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	3 (0.6)
Striped Skunk (*Mephitis mephitis*)	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2 (0.4)
Weasel (*Mustela* sp.)	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2 (0.4)
Grizzly Bear (*Ursus arctos*)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1 (0.2)
Mink (*Mustela vison*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1 (0.2)
Birds																
Common Raven (*Corvus corax*)	8	7	17*	8	0	29	24†	12	14	12	2	6	4	0	9	152 (29.1)
Golden Eagle (*Aquila chrysaetos*)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2 (0.4)
Bald Eagle (*Haliaeetus leucocephalus*)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1 (0.2)
Canada Jay (*Perisoreus canadensis*)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1 (0.2)

Sources, by year: 1–7: AESRD (2012), Hervieux *et al.* (2014: Tables S2, S3), Government of Alberta (2018); 8: AESRD (2012), Health Canada (2013), Government of Alberta (2018); 9, 10: Government of Alberta (2018); 11: D. Hervieux pers. comm. (2022); 12, 13: Government of Alberta (2018); 14: Government of Alberta (2019a); 15: Government of Alberta (2020).
Note: Shaded columns indicate years in which the strychnine program was not conducted.
*Discrepancy in data, where AESRD (2012) and Hervieux *et al.* (2014: Table S3) indicate 16 toxicant kills.
†Discrepancy in data, where AESRD (2012) and Hervieux *et al.* (2014: Table S3) indicate 23 toxicant kills.

further underreporting of strychnine kills. Although the search effort for both target and non-target species killed during the program discussed here was unknown, strychnine-poisoned wolves have been found at distances >1 km from poisoned baits (Rettie 1958; Harris and Armstrong 2021). Furthermore, evidence of mortality may be obscured by snow burial or other weather conditions which cannot be mitigated. For example, in winter 2008/2009, records indicate that although 16 wolves were documented as killed by strychnine, "additional wolves [were] not recovered due to poor snow conditions" (AESRD 2012: 5).

The use of poison as a wildlife management tool is highly controversial because of its reputation for causing prolonged suffering and broad damage (i.e., non-selectivity; Cluff and Murray 1995; Brook *et al.* 2015; Proulx *et al.* 2016a; Field *et al.* 2019; Parr and Barron 2021). Given the limited datasets used in my study, it was not possible to infer population-level effects or impacts on community ecology. However, it is worth noting that the data include species that have been designated by the provincial government as "sensitive" (Canada Lynx, Fisher, Golden Eagle) and "at-risk" (Grizzly Bear; AEP 2022). Grizzly Bear is also listed as a species of Special Concern under the Canadian *Species at Risk Act*, schedule one (SARA Registry 2023). At least one Grizzly Bear was killed by strychnine during winter 2012/2013 (Government of Alberta 2018). Public accounts with photo evidence have also been reported to the PMRA by local citizens with registered traplines in the area, suggesting that Grizzly Bear poisoning has occurred more frequently (D. Handy and S. Ramstead unpubl. data) and that additional animals killed by strychnine have gone unrecorded (see Health Canada 2018).

Proulx *et al.* (2016a) point out that the use of strychnine to kill wolves is in contravention of guidelines for the Canadian Council on Animal Care (CCAC 2003, 2023), the American Veterinary Medical Association (AVMA 2013, 2020), the Canadian

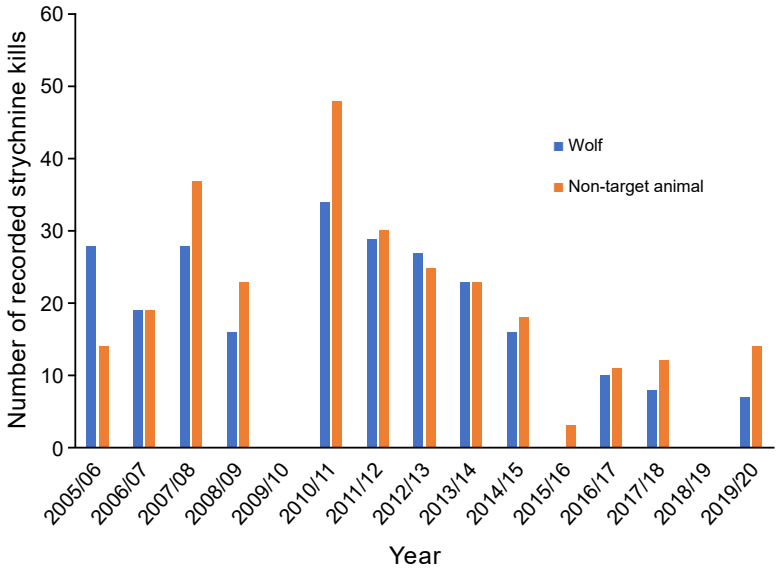

FIGURE 1. Numbers of wolves and non-target animals killed in each year of Alberta's annual winter wolf-strychnine program, 2005–2020. Of 522 recorded kills by strychnine, 46.9% were target animals (wolves, n = 245), while 53.1% were incidental kills of non-target organisms (n = 277), comprising ten mammal and four bird species.

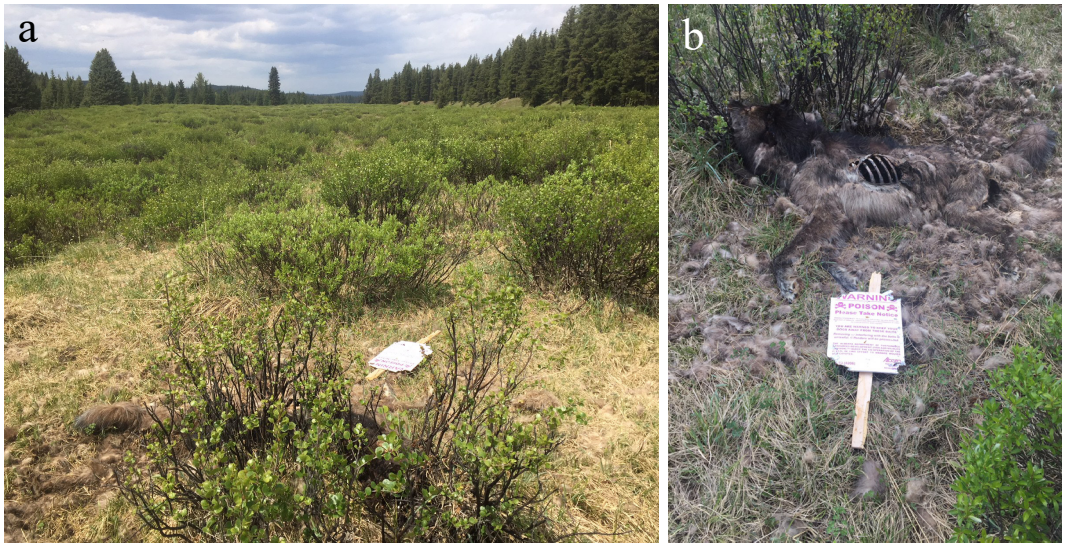

FIGURE 2. Strychnine bait station from Alberta's wolf-strychnine program, 8 June 2018. a. This station was located near forest cover where poisoned animals may move before dying, making kills more difficult to find. b. Close-up image of the scene showing poison-use sign and strychnine-killed wolf carcass. Photos: Darcy Handy.

Veterinary Medical Association (CVMA 2014, 2022), and the American Society of Mammalogists (Sikes *et al.* 2011). The International Union for Conservation of Nature does not condone poisoning wolves (IUCN Wolf Specialist Group of the Species Survival Commission 2000).

Many people, including scientists, argue that animal welfare should be sufficient grounds for ending the use of strychnine (Paquet and Darimont 2010; Dubois *et al.* 2017; Parr and Barron 2021). Contrary to this sentiment, following a consultation period on "humane vertebrate pest control", Health Canada announced in 2021 that the PMRA would "not be taking steps towards incorporating humaneness

considerations into the pesticide risk assessment framework" (PMRA 2021). Although the PMRA may have determined that the level of suffering to individual animals and the environmental risk of non-target deaths to terrestrial organisms is acceptable, many disagree with this assessment (Cluff and Murray 1995; Bekoff 2014; Brook *et al.* 2015; Proulx *et al.* 2016a,b, 2017; Dubois *et al.* 2017; Wolf Awareness 2018; Mitchell 2020; Health Canada 2021b; Weber 2020, 2021; Animal Alliance of Canada 2023). According to a national poll, commissioned by non-governmental organizations and carried out by Environics in 2020, 69% of Canadians say that the risks posed by predacides used in Canadian wildlife management programs are unacceptable (Animal Justice 2022; S.P. unpubl. data). Local Indigenous Peoples, specifically those of the Aseniwuche Winewak Nation, have also expressed their disdain for the Alberta government's use of strychnine as part of caribou recovery efforts, despite having a deep connection with caribou and a strong desire for their recovery (Denhoff 2016). Currently, Alberta is the sole province in Canada with authorized permits, which are registered through Health Canada's PMRA, for predacide use (strychnine and sodium monofluoroacetate). Outside of Alberta, provinces and territories with caribou recovery efforts underway, including British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, Northwest Territories, and Nunavut, do not use these toxicants. Of note, in the caribou ranges of Alberta where strychnine is used, the level of industrial disturbance has increased since the lethal wolf reduction program began in 2005 (Hervieux *et al.* 2014; Hebblewhite 2017; Nagy-Reis *et al.* 2021), indicating a lack of willingness by Alberta's government to address the ultimate causes of decline and favouring instead other stop-gap measures.

Health Canada's PMRA is undergoing a re-evaluation of the uses of predacidal strychnine and sodium monofluoroacetate and their associated end-use products (Health Canada 2022). Following an initial process of re-evaluation which included a review of the data presented here, on 31 August 2022, the PMRA announced a proposal to continue registration of predacidal strychnine and sodium monofluoroacetate (Health Canada 2022).

In summary, I have shown that from 2005 to 2020, west-central Alberta's wolf-strychnine program killed more non-target animals than wolves, including various bird and mammal species. A variety of non-target animal species were killed in the program, including federally listed species-at-risk and domestic animals. Management agencies considering the use of poison as part of wildlife management programs should carefully consider the ethical and environmental costs associated with such programs, which here have included the suffering and death of both the target species and a significant number (>50%) of non-target animals.

Note

As of 7 March 2024 Health Canada's Pest Management Regulator Agency announced that all predacide uses of strychnine products in Canada have been cancelled. Alberta was the only province that allowed the use of this predacide. After the six-month phasing out period ends in early September 2024, strychnine will no longer be permitted/legal to use. See https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates/reevaluation-decision/2024/predacide-uses-strychnine-sodium-monofluoroacetate.html. Information contained in the current paper contributed to this ruling.

Acknowledgements

Dave Hervieux (Provincial Woodland Caribou Management Coordinator, Fish and Wildlife Stewardship Branch, Alberta Environment and Parks, and Regional Director in Northwest Region) provided data for the winter of 2015/2016 by personal communication via email on 18 January 2022. Darcy Handy (Registered Fur Management Area holder with a cabin close to Alberta's wolf-strychnine program) provided photographs and information about field observations of carcasses found at signed bait sites. Shane Ramstead (retired Government of Alberta Fish and Wildlife officer and Registered Fur Management Area holder with a cabin near Alberta's wolf-strychnine program) provided information about field observations of carcasses found at signed bait sites. I also thank Carol and Peter Tracey and recognize, with appreciation, important contributions from Associate Editor Brent Patterson, as well as Liz White, Hannah Barron, Kaitlyn Mitchel, Kirsten Weagle, Sheryl Fink, Barry MacKay, Gilbert Proulx, and the following organizations: Animal Alliance of Canada, Animal Justice, the International Foundation for Animal Welfare, Wolf Awareness, and Humane Society International/Canada. Additional gratitude goes to Wolf Awareness for covering the publication costs of this manuscript.

Literature Cited

AEP (Alberta Environment and Protected Areas). 2022. Alberta wild species general status listing — 2020. Government of Alberta, Edmonton, Alberta, Canada. Accessed 12 December 2023. http://tinyurl.com/34d2ye8m.

AESRD (Alberta Environment and Sustainable Resource Development). 2012. Alberta Environment and Sustainable Resource Development use of toxicants for

wildlife management. Government of Alberta, Edmonton, Alberta, Canada.

Allan, D.G. 1989. Strychnine poison and the conservation of avian scavengers in the Karoo, South Africa. South Africa Journal of Wildlife Research 19: 102–106.

AVMA (American Veterinary Medical Association). 2013. AVMA guidelines for the euthanasia of animals. Schaumburg, Illinois, USA.

AVMA (American Veterinary Medical Association). 2020. AVMA guidelines for the euthanasia of animals. Schaumburg, Illinois, USA. Accessed 8 February 2024. https://www.avma.org/sites/default/files/2020-02/Guidelines-on-Euthanasia-2020.pdf.

Animal Alliance of Canada. 2023. Help ban poisons. Animal Alliance of Canada, Toronto, Ontario, Canada. Accessed 14 February 2023. https://www.animalalliance.ca/help-ban-poisons/.

Animal Justice. 2022. [Media Release] Animal Justice slams Health Canada over cruel poisons to kill wolves and other wildlife. Animal Justice, Toronto, Ontario, Canada. Accessed 9 February 2023. https://animaljustice.ca/media-releases/animal-justice-slams-health-canada-over-cruel-poisons-to-kill-wolves-and-other-wildlife.

Bekoff, M. 2014. Killing 890 wolves to learn about them: something's wrong. Psychology Today: 2 December. Accessed 21 June 2022. https://www.psychologytoday.com/ca/blog/animal-emotions/201412/killing-890-wolves-learn-about-them-somethings-wrong.

Brook, R.K., M. Cattet, C.T. Darimont, P.C. Paquet, and G. Proulx. 2015. Maintaining ethical standards during conservation crises. Canadian Wildlife Biology and Management 4: 72–79. Accessed 21 June 2022. https://www.wellbeingintlstudiesrepository.org/ethcbio/3/.

Cain, S.A., J.A. Kadlec, D.L. Allen, R.A. Cooley, M.G. Hornocker, A.S. Leopold, and F.H. Wagner. 1972. Predator control — 1971: report to the Council on Environmental Quality and the Department of the Interior. University of Michigan, Ann Arbor, Michigan, USA. Accessed 18 November 2022. https://tinyurl.com/2catjs4d.

CCAC (Canadian Council on Animal Care). 2003. CCAC guidelines on: the care and use of wildlife. Ottawa, Ontario, Canada.

CCAC (Canadian Council on Animal Care). 2023. CCAC guidelines: wildlife. Ottawa, Ontario, Canada. Accessed 8 February 2024. https://ccac.ca/Documents/Standards/Guidelines/CCAC_Guidelines-Wildlife.pdf.

CVMA (Canadian Veterinary Medical Association). 2014. Pest control position statement. Ottawa, Ontario, Canada.

CVMA (Canadian Veterinary Medical Association). 2022. Pest management statement. Accessed 8 February 2023. https://www.canadianveterinarians.net/policy-and-outreach/position-statements/statements/pest-management/.

Cluff, H.D., and D.L. Murray. 1995. Review of wolf control methods in North America. Pages 491–607 *in* Ecology and Conservation of Wolves in a Changing World. *Edited by* L.N. Carbyn, S.H. Fritts, and D.R. Seip. Canadian Circumpolar Institute, Edmonton, Alberta, Canada.

Denhoff, E. 2016. Setting Alberta on the path to caribou recovery. Government of Alberta, Edmonton, Alberta, Canada. Accessed 9 October 2023. https://open.alberta.ca/dataset/setting-alberta-on-the-path-to-caribou-recovery.

Dubois, S., N. Fenwick, E.A. Ryan, L. Baker, S.E. Baker, N.J. Beausoleil, S. Carter, B. Cartwright, F. Costa, C. Draper, and J. Griffin. 2017. International consensus principles for ethical wildlife control. Conservation Biology 31: 753–760. https://doi.org/10.1111/cobi.12896

Eason, C.T., and M. Wickstrom. 2001. Vertebrate pesticide toxicology manual (poisons): information on poisons used in New Zealand as vertebrate pesticides. Department of Conservation technical series 23. Department of Conservation, Wellington, New Zealand. Accessed 18 November 2022. https://www.doc.govt.nz/documents/science-and-technical/docts23.pdf.

Field, K.A., P.C. Paquet, K. Artelle, G. Proulx, R.K. Brook, and C.T. Darimont. 2019. Publication reform to safeguard wildlife from researcher harm. PLoS Biology 17: e3000193. https://doi.org/10.1371/journal.pbio.3000193

Fritts, S.H. 1993. Controlling wolves in the greater Yellowstone area. Pages 173–233 *in* Ecological Issues on Reintroducing Wolves into Yellowstone National Park. *Edited by* R.S. Cook. US Department of the Interior National Park Service, Washington, DC, USA.

Government of Alberta. 2018. Summary of Little Smoky Caribou range toxicant program 2005/06–2017/18; no toxicant program delivery in 2009/10 and 2015/16. Access request E18-G-1236. Government of Alberta, Edmonton, Alberta, Canada. Accessed 9 October 2023. https://4bd11b70-bb62-41e7-b771-dc68a1920500.usrfiles.com/ugd/4bd11b_5ff873ce2ffd49deafafd384a8ac4710.pdf.

Government of Alberta. 2019a. Closure letter no records available strychnine for caribou. Access request E19-G-0773. Government of Alberta, Edmonton, Alberta, Canada. Accessed 9 October 2023. https://4bd11b70-bb62-41e7-b771-dc68a1920500.usrfiles.com/ugd/4bd11b_d3eeabbec271448b983aabe34dc687ec.pdf.

Government of Alberta. 2019b. Strychnine program and record request. Access request E19-G-0389. Government of Alberta, Edmonton, Alberta, Canada. Accessed 9 October 2023. https://4bd11b70-bb62-41e7-b771-dc68a1920500.usrfiles.com/ugd/4bd11b_9f828d4b4b014160b9163bab4ae06fba.pdf.

Government of Alberta. 2020. Site establishment, checks, closing dates — Little Smoky caribou range — January–July 2020. Access request E20-G-0611. Government of Alberta, Edmonton, Alberta, Canada. Accessed 9 October 2023. https://4bd11b70-bb62-41e7-b771-dc68a1920500.usrfiles.com/ugd/4bd11b_912837887239488c854c9cfc5e495609.pdf.

Harris, A.G., and T.E.R. Armstrong. 2021. An overview of experimental Gray Wolf (*Canis lupus*) poisoning programs in northern Ontario, 1956 to 1964. Canadian Field-Naturalist 135: 142–152. https://doi.org/10.22621/cfn.v135i2.2293

Health Canada. 2013. Incident report details. Incident report 2013-2771. Pesticide product information database. Health Canada, Ottawa, Ontario, Canada. Accessed 15

May 2022. https://pest-control.canada.ca/pesticide-registry/en/incident-report-details.html?q=2013-2771.

Health Canada. 2018. Incident report details. Incident report 2018-5366. Pesticide product information database. Health Canada, Ottawa, Ontario, Canada. Accessed 15 May 2022. https://pest-control.canada.ca/pesticide-registry/en/incident-report-details.html?q=2018-5366.

Health Canada. 2020. Re-evaluation decision RVD2020-06: strychnine and its associated end-use products (Richardson's Ground Squirrels). Health Canada, Ottawa, Ontario, Canada. Accessed 22 June 2022. https://tinyurl.com/3xb6puuu.

Health Canada. 2021a. Registration no. 24510: strychnine predacide skunk control product label. Health Canada, Ottawa, Ontario, Canada. Accessed 26 March 2024. https://pr-rp.hc-sc.gc.ca/l_1/view_label?p_ukid=310018802.

Health Canada. 2021b. Consultation summary — humane vertebrate pest control. Incident report Pest Management Regulatory Agency, Government of Canada, Ottawa, Ontario, Canada. Accessed 9 February 2023. http://tinyurl.com/mbsyzh75.

Health Canada. 2022. Proposed re-evaluation decision PRVD2022-18: predacide uses of strychnine and sodium monofluoroacetate and their associated end-use products. Pest Management Regulatory Agency, Government of Canada, Ottawa, Ontario, Canada. Accessed 2 February 2023. http://tinyurl.com/3fdc48xe.

Health Canada. 2023. Registration no. 20410: strychnine wolf, coyote and black bear control predacide product label. Health Canada, Ottawa, Ontario, Canada. Accessed 26 March 2024. https://pr-rp.hc-sc.gc.ca/l_1/view_label?p_ukid=310016852.

Hebblewhite, M. 2017. Billion dollar boreal woodland caribou and the biodiversity impacts of the global oil and gas industry. Biological Conservation 206: 102–111. https://doi.org/10.1016/j.biocon.2016.12.014

Hervieux, D., M. Hebblewhite, D. Stepnisky, M. Bacon, and S. Boutin. 2014. Managing wolves (*Canis lupus*) to recover threatened woodland caribou (*Rangifer tarandus caribou*) in Alberta. Canadian Journal of Zoology 92: 1029–1037. http://doi.org/10.1139/cjz-2014-0142

IUCN Wolf Specialist Group of the Species Survival Commission. 2000. Manifesto: declaration of principles for wolf conservation. World Conservation Union, Gland, Switzerland. Accessed 12 December 2023. https://www.scribd.com/document/134982770/IUCN-Wolf-Specialist-Group-Manifesto-on-wolf-conservation-2000.

Khan, S.A. 2010. Overview of strychnine poisoning. Merck Veterinary Manual, 10th Edition. *Edited by* C.M. Kahn and S. Line. Merck & Co., Whitehouse Station, New Jersey, USA.

Kolenosky, G.B. 1983. Status and management of wolves in Ontario. Pages 35−40 *in* Wolves in Canada and Alaska: Their Status, Biology, and Management. Proceedings of the Wolf Symposium, Edmonton, Alberta, 12–14 May 1981. Report series 45. *Edited by* L.N. Carbyn. Canadian Wildlife Service, Ottawa, Ontario, Canada.

Mitchell, K. 2020. Groups call on Canada to stop the cruel & irresponsible poisoning of Wolves, Coyotes, & Black Bears. Animal Justice, Toronto, Ontario, Canada. Accessed 14 February 2023. https://animaljustice.ca/blog/groups-call-on-canada-to-stop-the-cruel-irresponsible-poisoning-of-wolves-coyotes-black-bears.

Nagy-Reis, M., M. Dickie, A.M. Calvert, M. Hebblewhite, D. Hervieux, D.R. Seip, S.L. Gilbert, O. Venter, C. DeMars, S. Boutin, and R. Serrouya. 2021. Habitat loss accelerates for the endangered woodland caribou in western Canada. Conservation Science and Practice 3: e437. https://doi.org/10.1111/csp2.437

Paquet, P.C., and C.T. Darimont. 2010. Wildlife conservation and animal welfare: two sides of the same coin. Animal Welfare 19: 177–190. https://doi.org/10.1017/s0962728600001433

Parr, S., and H.R. Barron. 2021. Indiscriminate, inhumane, and irresponsible: compound 1080 is no longer an acceptable form of wildlife management. Canadian Wildlife Biology and Management 10: 33–41. Accessed 21 November 2022. http://tinyurl.com/yb6ytfw4.

PMRA (Pest Management Regulatory Agency). 2005. Re-evaluation of strychnine. PACR2005-08. Health Canada, Ottawa, Ontario, Canada. Accessed 14 February 2023. https://publications.gc.ca/collections/Collection/H113-18-2005-8E.pdf.

PMRA (Pest Management Regulatory Agency). 2020a. Environmental Assessment Directorate monograph: re-evaluation of the predacide cluster: strychnine and sodium monofluoroacetate. Access to information and privacy request no. 3249390. Health Canada, Ottawa, Ontario, Canada.

PMRA (Pest Management Regulatory Agency). 2020b. Spreadsheet compiled by the PMRA for all strychnine use records provided by the registrant and users that were considered in the re-evaluation. Access to information and privacy request no. 3249569. Health Canada, Ottawa, Ontario, Canada.

PMRA (Pest Management Regulatory Agency). 2021. Consultation summary – humane vertebrate pest control. Health Canada, Ottawa, Ontario, Canada. Accessed 18 November 2022. http://tinyurl.com/mbsyzh75.

Proulx, G., S.M. Alexander, H.R. Barron, M. Bekoff, R. Brook, H. Bryan, M. Cattet, C. Darimont, V. Lukasik, R. Darvill, S. Dubois, W.P. McCrory, P. Paquet, S. Parr, R. Powell, A. Treves, A.V. Stronen, J.A. Vucetich, and A. Wallach. 2016b. Open letter from scientists and scholars about the Little Smoky caribou range plan. Nature Alberta 46: 8–9. Accessed 21 June 2022. https://www.researchgate.net/publication/311583834_Open_letter_from_scientists_and_scholars_about_the_Little_Smoky_caribou_range_plan.

Proulx, G., S.M. Alexander, H.R. Barron, M. Bekoff, R. Brook, H. Bryan, C. Darimont, S. Dubois, V. Lukasik, W.P. McCrory, P. Paquet, S. Parr, R. Powell, A.V. Stronen, and A. Wallach. 2017. Killing wolves and farming caribou benefit industry, not caribou: a response to Stan Boutin. Nature Alberta 47: 4–10. Accessed 21 June 2022. https://www.researchgate.net/publication/317592636_Killing_wolves_and_farming_caribou_benefit_industry_not_caribou_a_response_to_Stan_Boutin.

Proulx, G., R.K. Brook, M. Cattet, C. Darimont, and P.C.

Paquet. 2016a. Poisoning wolves with strychnine is unacceptable in experimental studies and conservation programmes. Environmental Conservation 43: 1–2. http://doi.org/10.1017/s0376892915000211

Rettie, C.A. 1958. Predator control — wolf poisoning, Port Arthur District, 1957–58. Fish and wildlife management report 43. Ontario Department of Lands and Forests, Nipigon, Ontario, Canada.

SARA (*Species at Risk Act*) Registry. 2023. Species summary: Grizzly Bear (*Ursus arctos*), Western population. Government of Canada, Ottawa, Ontario, Canada. Accessed 13 December 2023. https://species-registry.canada.ca/index-en.html#/species/1195-863.

Sikes, R.S., W.L. Gannon, and Animal Care and Use Committee. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92: 235–253. https://doi.org/10.1644/10-mamm-f-355.1

USEPA (US Environmental Protection Agency). 1980. Strychnine position document no. 2/3. United States Environmental Protection Agency, Washington, DC, USA; page 43. Accessed 12 December 2023. http://tinyurl.com/33kwhwc7.

Vucetich, J., and M.P. Nelson. 2014. Wolf hunting and the ethics of predator control. Pages 411–429 *in* Oxford Handbook of Animal Studies. *Edited by* L. Kalof. Oxford University Press, New York, New York, USA. https://doi.org/10.1093/oxfordhb/9780199927142.013.007

Wallach, A.D., M. Bekoff, M.P. Nelson, and D. Ramp. 2015. Promoting predators and compassionate conservation. Conservation Biology 29: 1481–1484. http://doi.org/10.1111/cobi.12525

Wallach, A.D., E.G. Ritchie, J. Read, and A.J. O'Neill. 2009. More than mere numbers: the impact of lethal control on the social stability of a top-order predator. PLoS ONE 4: e6861. https://doi.org/10.1371/journal.pone.0006861

Wasser, S.K., J.L. Keim, M.L. Taper, and S.R. Lele. 2012. To kill or not to kill — that is the question. Frontiers in Ecology and the Environment 10: 67–68. http://doi.org/10.1890/12.WB.006

Weber, B. 2020. Alberta's use of poison as wolf control criticized, feds asked to review. Global News, Vancouver, British Columbia, Canada. Accessed 9 February 2023. https://globalnews.ca/news/7530444/alberta-wolf-control-strychnine-poison/.

Weber, B. 2021. Health Canada says it won't consider cruelty to animals in strychnine review. Globe and Mail, Toronto, Ontario, Canada. Accessed 9 February 2023. https://www.theglobeandmail.com/canada/article-health-canada-says-it-wont-consider-cruelty-to-animals-in-strychnine/.

Wolf Awareness. 2018. An open letter to the Minister of Health and Canada's Pest Management Regulatory Agency regarding the use of strychnine, sodium monofluoroacetate (compound 1080), and sodium cyanide to kill wildlife in Canada. Accessed 9 February 2023. https://www.researchgate.net/publication/368390724.

Received 15 August 2022
Accepted 13 December 2023
Associate Editor: B. Patterson