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An overview of experimental Gray Wolf (*Canis lupus*) poisoning programs in northern Ontario, 1956 to 1964

Allan G. Harris[1,*] and Ted (Edward) R. Armstrong[2]

[1]Northern Bioscience, 136 S. Hill Street, Thunder Bay, Ontario P7B 3V1 Canada
[2]615 Rosewood Crescent, Thunder Bay, Ontario P7E 2R5 Canada
[*]Corresponding author: aharris@tbaytel.net

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Abstract

In the late 1950s, the Ontario Department of Lands and Forests commenced an experimental Gray Wolf (*Canis lupus*) poisoning program in northern Ontario, the results of which were documented in a series of unpublished reports. Most projects consisted of distributing baits poisoned with strychnine on frozen lakes in late winter; 12 were conducted by district staff and typically consisted of <10 bait stations monitored for two to four months. An intensive three-year program was completed in the Allanwater area, about 250 km north of Thunder Bay, where up to 56 bait stations were distributed on a grid covering >25 000 km^2. Thirty eight wolf kills were reported in the district projects and 81 in the Allanwater study. In total, where sex was identified 56% were male and 44% female. Adults made up 51% of the kill in the Allanwater study, subadults (<2 years old) 44%, and 5% were of unknown age. Two hundred and sixty five kills of species other than wolves were documented from all studies, comprising 10 mammal and nine bird species. Common Raven (*Corvus corax*) and Red Fox (*Vulpes vulpes*) made up 54% and 24% of the non-target mortality, respectively, and were recorded in most studies. Kills of wolves and non-target species were probably under-reported because animals left bait stations before dying, were buried by snow, were removed by bounty hunters, or monitoring for non-target species was poor. Although completed over 50 years ago, the studies summarized here provide context on the ecological impacts and ethics of poison use to control wolves.

Key words: Predator control; poison; strychnine; Ontario; non-target mortality; Gray Wolf; Common Raven; Red Fox

Introduction

Gray Wolves (*Canis lupus*) are broadly distributed across northern Ontario, occurring from the Manitoba to the Quebec border, and from the Upper Great Lakes north to the Hudson Bay coast (Ontario Ministry of Natural Resources 2005; Naughton 2012). During the late 19th century and well past the mid-20th century, Gray Wolves were considered a significant predator that needed to be controlled due to perceived impacts on populations of Moose (*Alces americanus*), White-tailed Deer (*Odocoileus virginianus*), and livestock (Pimlott 1961). Control programs included year-round hunting seasons, bounties, shooting from aircraft, and poisoning. Wolf poisoning was widely conducted in Ontario in the 1800s and early 1900s (Omand 1950; Kolenosky 1983). Prior to 1911, poisoning was the "most usual and effective method for the destruction of wolves" (Anonymous 1912: 215). By 1911, the use of poison to kill wolves remained legal, but placing poison where other furbearers could be killed was illegal, effectively limiting its use (Anonymous 1912). Poisoning was the principal means of wolf control in Algonquin Provincial Park from 1893 until about 1933 when it was replaced by snaring (Pimlott *et al.* 1969). By the late 1960s poisoning wolves was discouraged by the Ontario Department of Lands and Forests (Kolenosky *et al.* 1978) and by the early 1980s, the use of strychnine, sodium fluoroacetate ("Compound 1080"), and cyanide was prohibited (Kolenosky 1983). Bounties for wolves were initiated in Ontario in 1793 (Theberge 1973) and phased out in 1972 (Cluff and Murray 1995). Predator control for wildlife management has not been conducted in Ontario since the mid-1980s (Ontario Ministry of Natural Resources 2005). Wolves are classified as furbearers in Ontario and the use of poison to control them is now prohibited under the 1997 *Fish and Wildlife Conservation Act*.

Although no longer occurring in Ontario, wolf poisoning programs continue to be used elsewhere in North America and remain controversial (Proulx *et al.* 2015). Despite being widely used across northern Ontario in the past, there is little published

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documentation of the history and possible legacy of Gray Wolf control programs.

In the late 1950s, the Ontario Department of Lands and Forests initiated an experimental Gray Wolf poisoning program in northern Ontario. The initial programs (1956–1961) were conducted by district staff under a directive from the Division of Research (Pimlott *et al.* 1961). The objectives were generally to determine (1) the effectiveness of various poisons on wolves, (2) the impacts on non-target species, (3) the effectiveness of different baits and methods of deployment, and (4) cost.

Some studies were more specifically intended to increase local abundance of Moose or White-tailed Deer populations (e.g., Turner 1959) or reduce livestock depredation (e.g., Chrysler 1960).

A more systematic study was conducted between 1960 and 1964 in the Allanwater area about 250 km north of Thunder Bay (Pimlott *et al.* 1961). The objectives of that study (Pimlott *et al.* 1961: 1) were:

1) To obtain specific information on the mechanics of controlling a Timber Wolf population in a forested habitat.
2) To determine the effect that poison baits placed on lakes will have on other mammals and birds.
3) To determine the type of situation and type of poison baits that minimize the loss of other mammals and birds.
4) To determine the economics of a poisoning program conducted in a large area.
5) To obtain detailed information on the sex and age composition of wolf packs.

Many of the data from these studies were included in unpublished Ontario Department of Lands and Forests reports but have not been reported in peer-reviewed literature. We present the history of the Ontario experimental wolf poisoning program conducted between 1956 and 1964 and summarize data on wolves and non-target species killed during this program.

Methods

We reviewed and compiled all available Fish and Wildlife Management Reports (n = 16) describing wolf poisoning studies in northern Ontario found in the Ontario Ministry of Natural Resources Library in Peterborough, Ontario, Canada. Reports documented various regional poisoning initiatives in addition to a three-year poisoning program (Allanwater Research Study) and contained varying levels of detail on study methods and results.

District studies 1956 to 1961

We found reports of 12 studies conducted between 1956 and 1961 by Ontario Department of Lands and Forests staff in district offices under the general direction of the Lands and Forests Research Branch (Pimlott 1961). These studies were conducted in Fort Frances, Kenora, Sioux Lookout, Port Arthur, Nipigon, and Gogama districts and included observations at 48 different bait stations (Figure 1; Table 1).

Baits were placed on frozen lakes and anchored with bricks or other weights or frozen into the ice surface, except in the Rainy River study where baits were placed on land (Chrysler 1960). Baits were generally left to sink into the lake in the spring. At Kenora in 1961, baits were covered with evergreen branches in an effort to reduce kills of non-target species (Linklater 1961). The rationale for choosing bait locations was not always provided, but sometimes attempted to eliminate specific packs of wolves found at Moose or White-tailed Deer kill sites (e.g., Swift 1959), or were arranged on a convenient route for rechecking the baits.

Baits usually included Moose, White-tailed Deer, or American Beaver (*Castor canadensis*) carcasses. Fish, Northern River Otter (*Lontra canadensis*), Domestic Sheep (*Ovis aries*), and Horse (*Equus caballus*) carcasses were used in a few instances (Table 1). Cubes of deer, rather than larger portions of carcasses, were used by Linklater (1959).

Strychnine was the most commonly used poison (11 programs) although sodium fluoroacetate was used for three seasons at Kenora, and cyanide was used along with strychnine at Port Arthur in 1957 (Table 1). Strychnine pellets or cubes were inserted into the bait and sealed with a plug of meat or fat. Powdered cyanide and strychnine were sifted into slits cut into the bait. Sodium fluoroacetate was impregnated into the bait (cubes of deer) in the laboratory and then shipped to the field (Linklater 1960). In Kenora in 1959, the study area was pre-baited with deer meat in an effort to habituate wolves to the bait (Linklater 1959).

Bait stations were checked between one and 30 days after the poison was deployed and evidence of wolf and other wildlife mortality was recorded. The frequency of checks varied within and between programs and was often unreported. Most bait stations were accessed by aircraft, but some were checked by vehicle or on foot where access was possible. Effort to document non-target (i.e., species other than wolves) wildlife mortality was highly variable within and between programs and was usually poorly documented. At Kenora, Linklater (1956, 1960, 1961) specifically indicated that methods included an attempt to determine non-target mortality, although only cursory examinations consisting of an aircraft flyover were conducted on some dates (Linklater 1959, 1960,

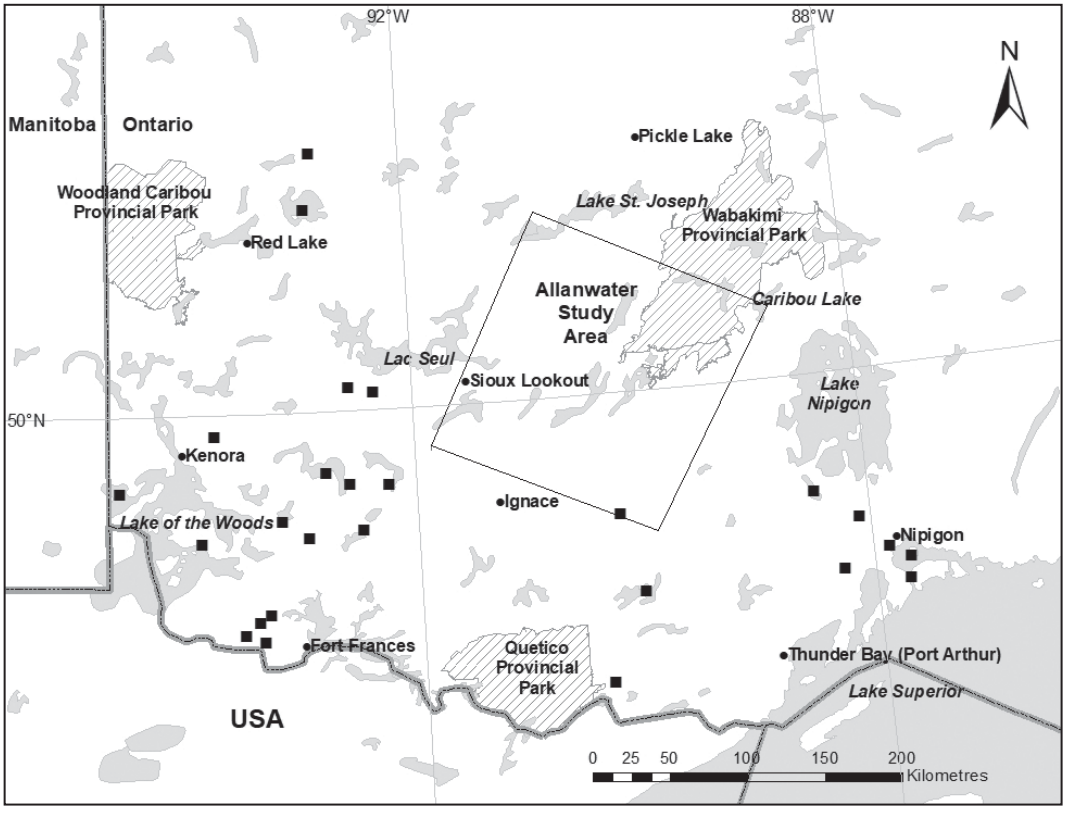

Figure 1. Experimental Gray Wolf (*Canis lupus*) poisoning bait locations in northwestern Ontario (1956–1964), including the Allanwater study area. Squares indicate the approximate locations of bait stations. The Gogama study area is about 430 km east of the area shown on the map.

1961). The Port Arthur program in 1959 apparently did not search for non-target mortality (Swift 1959).

Allanwater study

The Allanwater study was conducted between 1960 and 1964 by staff of the Ontario Department of Lands and Forests Research Branch under the direction of D.H. Pimlott and J. Shannon as part of the Ontario Wolf Research Program. The study area was a 161 km × 161 km (25 921 km^2) block between Sioux Lookout and Armstrong, roughly bordered by Lac Seul to the west, Lake St. Joseph to the north, Caribou Lake to the east, and Ignace to the south (Figure 1). It encompassed what is presently the southern part of Wabakimi Provincial Park. In the early 1960s, the area was a remote and undisturbed part of the Boreal Forest Region. The dominant vegetation consists of Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh), White Spruce (*Picea glauca* (Moench) Voss), Balsam Fir (*Abies balsamea* (L.) Miller), Trembling Aspen (*Populus tremuloides* Michaux), White Birch (*Betula papyrifera* Marshall), and Jack Pine (*Pinus banksiana* Lambert) forest (Crins *et al.* 2009). Moose were the most common ungulate although Caribou (*Rangifer tarandus*) were locally present and were probably more common and widespread in the early 1960s. Moose densities in the more northern portion of the study area typically remained under 0.1/km^2 in recent decades (1980–2005; Ontario Ministry of Natural Resources 2013) and were likely similar during the 1960s. Road access in the 1950s and 1960s was confined to Highway 599 extending north from Savant Lake to Pickle Lake. Industrial forestry was largely confined to areas near Sioux Lookout and Savant Lake and along the Canadian National rail line (Ontario Ministry of Natural Resources and Bowater Canadian Forest Products Incorporated 2008).

A 22.5 km × 22.5 km grid was established in 1959 with bait stations "at the most favourable locations within a 5 mile [8 km] radius" of each of the 49 intersection points (Pimlott *et al.* 1961: 5). This spacing resulted in one bait station approximately every 518 km^2 as recommended by Loughry (1958) for

TABLE 1. Details of Gray Wolf (*Canis lupus*) poisoning programs in northern Ontario, 1956–1964.

Reference	Poison	Bait	Confirmed wolf pack in area	District	Period	No. stations	Bait-days	Wolves killed
Linklater 1956	Strychnine	Moose	Unknown	Kenora	January–April 1956	2	237	3
D'Agostini 1958	Cyanide, strychnine	Deer, fish	Yes	Port Arthur	January–February 1957	2	48	0
Rettie 1958	Powdered strychnine	Deer	Yes	Port Arthur	February–March 1956	1	>30	0
Rettie 1958	Powdered strychnine	Moose	Yes	Port Arthur	January–March 1958	2	122	4
Linklater 1959	1080	Moose	Yes	Kenora	March–April 1959	1	30	0
McKeown 1959	Unknown	Moose, deer, fish, beaver	Unknown	Port Arthur	February–April 1959	3	128	3
Sayers 1959	Powdered strychnine	Whitefish, deer	Yes	Sioux Lookout	February–March 1961	5	200	8
Swift 1959	Strychnine crystals, Strychnine powder	Deer, horse, beaver	Yes	Port Arthur	February–April 1959	3	>84	7
Turner 1959	Strychnine	Moose	Yes	Gogama	December 1958–March 1959	2	256	0
Chrysler 1960	Alkaloid strychnine cubes	Beaver	No (grid)	Rainy River	February–April 1960	16	749	2
Linklater 1960	1080	Deer, beaver	Yes	Kenora	January–May 1960	1	73	0
Linklater 1961	1080 and strychnine	Deer, beaver	Yes	Kenora	January–May 1961	10	1093	11
Allanwater research study								
Pimlott *et al.* 1961	Strychnine pellets	Beaver, deer, moose	No	Sioux Lookout and Port Arthur	ca. January–April 1960	56	4843	29
Shannon *et al.* 1961			Yes		January–May 1961	21	1649	14
Shannon *et al.* 1962			No		January–April 1962	55	4757	32
Shannon *et al.* 1963			Yes		March–April 1963	6	108	6

optimal density for controlling Gray Wolves in Caribou winter range. Additional bait stations were established in 1960 (56 stations total) and 1962 (55 stations total) apparently at the discretion of the field staff conducting the study. Baits were placed on frozen lakes between 23 and 137 m from the shore and wired to scrap iron or bricks, which were frozen into the ice. Baits consisted of Moose, White-tailed Deer, or American Beaver meat. Pellets containing 0.13 g (2 grains) of alkaloid strychnine were distributed in the bait at the rate of one pellet/0.45 kg of meat. In 1961 the protocol was modified in an attempt to increase the number of wolves killed. Rather than placing bait stations on a grid, baits were placed where wolves had been observed during a reconnaissance flight. Only 21 bait stations were established due to unfavourable weather and limited aircraft availability (Shannon *et al.* 1961). In 1963, only six bait stations were established, again where wolves had been observed during reconnaissance flights. Three stations operated from 6 to 11 March and the other three from 17 February to 1 April 1963 (Shannon *et al.* 1963).

Bait stations were checked by circling the site with a De Havilland Otter aircraft and searching for carcasses of wolves and other species. Flights were initially planned weekly (Pimlott *et al.* 1961) but often had to be delayed or cancelled due to weather conditions and aircraft availability (Shannon *et al.* 1961). Wolf carcasses were counted and identified to sex and age class (adult versus subadult [<2 years old]). Carcasses were collected and submitted to the Ontario Department of Lands and Forest research laboratory in Maple, Ontario for necropsy.

Aerial wolf surveys were conducted on seven occasions between December 1960 (before the initial poison deployment) and March 1964 (at the conclusion of the study; Table 2). Survey dates were chosen based on suitable snow for observing tracks and weather conditions for flying. Transects were flown by fixed-wing aircraft on a grid with 22.5 km spacing for a total survey transect length of 2253 km. Shannon *et al.* (1963) suggested that with 22.5 km survey line spacing, about half of the total wolf population is counted based on Shannon's personal experience conducting aerial surveys for wolves in Algonquin Park. Tracks of single wolves (as opposed to packs) were not included due to the difficulty in making positive species identification.

Results

Wolf mortality

A total of 119 wolf kills was reported across all studies (Table 1). No wolf mortality was observed in the 1956 (Rettie 1958) or 1957 Port Arthur (D'Agostini 1958) projects, the 1959 (Linklater 1959) or 1960 (Linklater 1960) Kenora projects, or the Gogama (Turner 1959) project. Kill rates varied widely by study from 0.0 to 83.3 kills per 1000 bait days (Table 3). In the Allanwater study, kill rates were similar in 1960 and 1962 (6.61 and 6.73 wolves per 1000 bait-days, respectively) when numbers and distribution of baits were similar.

Of the 110 wolves where sex was identified, 56% were male (62% in the 1956 to 1961 studies; 54% in the Allanwater study). In the Allanwater study, 51% were identified as adults, 44% as subadults, and 5% were of unknown age. Ages were not reported in other studies.

Up to 10 dead wolves were found at a single bait check in the Allanwater study in 1961: three adults, five subadults, and two apparent yearlings, probably from a single pack (Pimlott *et al.* 1961). Six dead wolves (three adult males and three adult females) at Allanwater in 1963 were assumed to constitute most or all of a single pack (Shannon *et al.* 1963).

Dead wolves were found at distances ranging from 0 m (dead with mouth on the bait; Swift 1959) to over 1.2 km (Rettie 1958) from the bait. A trapper reported tracking a wolf for 1.6 km from the bait before finding it dead (Pimlott *et al.* 1961). Three incidences of wolves eating the bait but no carcass being discovered were reported by Pimlott *et al.* (1961). In several

Table 2. Gray Wolf (*Canis lupus*) aerial survey results for the Allanwater study area. 1960–1964.

Source	Survey dates	Estimated # wolves*	# packs †
Pimlott *et al.* 1961	16–21 December 1960	125	25
Shannon *et al.* 1961	6–10 January 1961	54	11
Shannon *et al.* 1962	19–20 December 1961, 9 January 1962	63	21
Shannon *et al.* 1963	9–11 January 1963	25	NA
Shannon *et al.* 1963	19–21 March 1963	25	NA
Shannon *et al.* 1964	13 January–February 8 1964	46	18
Shannon *et al.* 1964	17–18 March 1964	59	14

*Observed or track counts.
†Including single animals.

TABLE 3. Kill rates of Gray Wolf (*Canis lupus*), Common Raven (*Corvus corax*), and Red Fox (*Vulpes vulpes*) in poisoning programs in northern Ontario, 1956–1964.

Study area	Year	Reference	Kills / 1000 bait days		
			Gray Wolf	Common Raven	Red Fox
Port Arthur	1958	D'Agostini 1958	0.0	0.0	0.0
	1959	McKeown 1959	23.4	23.4	7.8
	1959	Swift 1959	83.3	23.8	11.9
Nipigon	1955–56	Rettie 1958	0.0	0.0	100.0
	1957–58	Rettie 1958	32.8	8.2	24.6
Gogama	1958–59	Turner 1959	0.0	3.9	0.0
Rainy River	1960	Chrysler 1960	2.7	9.3	2.7
Kenora	1955–56	Linklater 1956	12.7	0.0	0.0
	1959	Linklater 1959	0.0	0.0	0.0
	1959–60	Linklater 1960	0.0	0.0	0.0
	1961	Linklater 1961	10.1	12.8	12.8
Sioux Lookout	1959	Sayers 1959	40.0	25.0	15.0
Allanwater	1960–61	Pimlott *et al.* 1961	6.6	7.2	0.8
	1961	Shannon *et al.* 1961	8.5	10.9	1.2
	1961–62	Shannon *et al.* 1962	6.7	11.6	6.1
	1962–63	Shannon *et al.* 1963	27.8	27.8	18.5

cases bounty hunters were suspected of collecting wolf carcasses. Any wolves poisoned between the final survey in April or May and ice-out (often several weeks) were not counted (e.g., Shannon *et al.* 1962).

Wolves frequently scavenged the carcasses of previously poisoned wolves as demonstrated by partially eaten wolf carcasses, the presence of large quantities of wolf hair in scats near baits, and wolf remains in gut contents during necropsies (Shannon *et al.* 1963). Several incidences of secondary poisoning were described, including this passage from Pimlott *et al.* (1961: 9):

> One [poisoned] wolf was 30 feet [9 m] from the bait, a second had died at the same distance from the bait and then had been dragged about 80 yards [73 m] by a third wolf which then ate its intestines and lungs. This wolf then went a further 120 yards [110 m], falling repeatedly as it went, before it died; it was then 30 yards [27 m] into the forest.

Multiple authors reported wolf tracks approaching the bait but not feeding, suggesting some avoidance of bait (Rettie 1958; Sayers 1959; Linklater 1959, 1960, 1961).

Non-target species

Total observed mortality of all non-target species is summarized in Table 4. Some assumptions were made about the identity of reported non-target species, e.g., "rabbit" was assumed to be Snowshoe Hare (*Lepus americanus*), "squirrel" was assumed to be Red Squirrel (*Tamiasciurus hudsonicus*), and "seagull" was assumed to be Herring Gull (*Larus argentatus*); in all three instances, these are the sole representatives of those taxa resident in the boreal forest of northwestern Ontario in the winter or early spring. Two hundred and sixty five non-target kills were documented, comprising 10 mammal and nine bird species. Common Raven (*Corvus corax*) and Red Fox (*Vulpes vulpes*) were the most common non-target mortalities, making up 54% and 24% of the total kills, respectively, and being recorded in 69% of all studies. The kill rate for Common Raven and Red Fox increased in the Allanwater study when baits were placed near active wolf packs rather than being placed on a grid (Table 3; Shannon *et al.* 1963). At least one case of secondary poisoning of non-target species was reported; a raven which had fallen about 274 m from the bait was partially eaten by a Red Fox, which was dead about 3.1 m from the raven (Pimlott 1961).

Avian non-target mortalities increased later in the winter as migrant birds (i.e., American Crow [*Corvus brachyrhynchos*], Herring Gull, Turkey Vulture [*Cathartes aura*], and Bald Eagle [*Haliaeetus leucocephalus*]) returned to the study area.

The greatest number and diversity of reported non-target kills occurred in the Rainy River study area (Chrysler 1960). This study differed from the

Table 4. Non-target species killed during Gray Wolf (*Canis lupus*) poisoning programs in northern Ontario, 1956–1964.

Species	Total observed mortality (% of all birds/mammals)	No. studies (%) reported in (n = 16)
Birds		
Common Raven (*Corvus corax*)	144 (79.1)	11 (69)
Herring Gull (*Larus argentatus*)	14 (7.7)	3 (19)
American Crow (*Corvus brachyrhynchos*)	9 (4.9)	2 (13)
Bald Eagle (*Haliaeetus leucocephalus*)	4 (2.2)	3 (19)
Woodpecker sp. (Picidae)	4 (2.2)	1 (6)
Canada Jay (*Perisoreus canadensis*)	2 (1.1)	2 (13)
Turkey Vulture (*Cathartes aura*)	2 (1.1)	2 (13)
Raptors (“hawks”)	2 (1.1)	2 (13)
Blue Jay (*Cyanocitta cristata*)	1 (0.5)	1 (6)
Total	182	
Mammals		
Red Fox (*Vulpes vulpes*)	64 (77.1)	11 (69)
Striped Skunk (*Mephitis mephitis*)	5 (6.0)	1 (6)
Fisher (*Pekania pennanti*)	4 (4.8)	4 (25)
Canada Lynx (*Lynx canadensis*)	2 (2.4)	2 (13)
Domestic Dog (*Canis lupus familiaris*)	2 (2.4)	1 (6)
Snowshoe Hare (*Lepus americanus*)	2 (2.4)	1 (6)
Rodents (“mouse”)	1 (1.1)	1 (6)
Red Squirrel (*Tamiasciurus hudsonicus*)	1 (1.1)	1 (6)
American Marten (*Martes americana*)	1 (1.1)	1 (6)
American Mink (*Neovison vison*)	1 (1.1)	1 (6)
Total	83	

others in that it was on land rather than on a frozen lake and was in a landscape that included roads and agricultural land. Six species incidentally killed at this site were not reported elsewhere (woodpecker sp. [Picidae], Canada Jay [*Perisoreus canadensis*], Blue Jay [*Cyanocitta cristata*], Striped Skunk [*Mephitis mephitis*], Domestic Dog [*Canis lupus familiaris*], and “mouse” [Rodentia]).

Discussion

Wolf poisoning to reduce predation on wildlife was widespread in Canada for over 100 years (Cluff and Murray 1995) but there are few data on the impacts on wolf populations or non-target species, particularly in the boreal forest. Wolves were poisoned in Wood Buffalo National Park to reduce predation on Wood Bison (*Bison bison*) between 1935 and 1940 and periodically until the 1960s, but there is no available information on the numbers of wolves or other species killed (Carbyn *et al.* 1993). An experimental study to reduce wolf predation on Caribou in northern Alberta in 2005 to 2012 is probably the most well documented (Hervieux *et al.* 2014). Other studies focussed on poisoning wolves (Bjorge and Gunson 1985) or Coyotes (*Canis latrans*; e.g., Allen *et al.* 1996; Wobeser *et al.* 2004) to protect livestock.

The northern Alberta study (Hervieux *et al.* 2014) documented higher mortality rates of wolves and other species than observed in the Ontario wolf poisoning program we have summarized here. In comparison to the Alberta study, the Allanwater study reported fewer dead wolves (7.5/1000 bait-days in Ontario versus 27/1000 bait-days in Alberta). Non-target species were similar except Coyotes made up 20% of the Alberta kills, whereas Coyotes were largely absent in northern Ontario when the Ontario studies took place. Common Ravens (9.8 killed/1000 bait-days versus 15.9 killed/1000 bait-days) and Red Fox (3.3 killed/1000 bait-days versus 31 killed/1000 bait-days) were also more commonly reported in Hervieux *et al.* (2014), possibly due to higher density of wolves and other species in Alberta, and/or a more rigorous study design (Hervieux *et al.* 2014).

The effectiveness of poisoning programs for controlling wolf populations cannot be assessed from the studies summarized here. Wolf survey flights were conducted before and after the Allanwater study, but the amount of wolf immigration and emigration, the

influence of bounty hunters and trappers, and the number of wolves killed but not detected remain unknown. For example, bounty hunters were killing wolves from aircraft in the Allanwater area while the study was taking place. Five wolves in one pack were killed by bounty hunters in late February 1963 (Shannon *et al.* 1963) and in Kenora District, "quite a few permits" were issued to hunt predatory animals from aircraft in 1956 (Linklater 1956: 2). Wolf mortality from poisoning would be underestimated if wolves moved into forest cover before dying, carcasses were removed by bounty hunters, or snow buried the carcasses. Most wolves likely died close to the bait stations, although one was located 1.6 km away (Pimlott *et al.* 1961). In an Alberta study most wolves died within 150 m of the bait, but some travelled up to 1 km before dying (Bjorge and Gunson 1985), while in south Texas all predators killed by strychnine were found within 188 m of the bait site, and all but one were found within 37 m (Beasom 1974). The level of search effort in many reports is poorly documented and some authors (e.g., McKeown 1959; Pimlott *et al.* 1961) acknowledged that recent snowfall compromised the search efficiency. Other factors including experience of searchers and time since carcass placement were not controlled in the studies summarized here, which could lead to highly variable results (Vyas 1999).

Weather and snow conditions probably influenced the number of wolves killed. Shannon *et al.* (1961) concluded that the low number of wolf kills in 1961 was caused by low snowfall in early winter, which allowed wolves to range freely through forested habitat rather than concentrating movements on lakes and rivers. Slush conditions in late winter may also have inhibited wolves from travelling on water bodies. In 1962, the monthly wolf kills in the Allanwater study increased between January and April, possibly due to wolves overcoming their caution about the bait, increased movements during the breeding season, and/or declining prey availability (Shannon *et al.* 1962).

Wolf poisoning in northwestern Ontario in the late 1800s and early 1900s may have contributed to declines in Common Raven populations in the region. Common Raven was by far the most common bird observed to succumb to poisoning (79% of all incidentally killed birds). In a recent western Canada study, Common Raven was also the most common non-target bird species killed (96%; Alberta Environment and Parks 2017). Ravens were reported as common in the Thunder Bay area in 1893 (Atkinson 1894) but were rare in the 1920s and 1930s (Dymond *et al.* 1928; Dear 1940; Baillie and Hope 1943; Snyder 1953). Common Raven populations in Ontario and elsewhere in North America declined in the early 20th century in part due to mortality caused by poisoning (Blomme 1987) and baited traps (Boarman and Heinrich 2020). Common Raven may be particularly vulnerable to poisoning efforts that target wolves given their propensity to follow wolf packs and feed on the kills (Stahler *et al.* 2002). This intentional association with wolf packs also serves to suppress the ravens' natural tendency to be suspicious of novel food sources (Stahler *et al.* 2002), potentially increasing their risk of consuming poisoned baits. Common Raven populations in the Kenora area in northwestern Ontario increased between the 1930s and early 1950s (Snyder 1953), following the decline in wolf poisoning. Common Raven control experiments in Nevada suggested that any reductions in raven populations were short-term and did not have long-term consequences because of the reoccupancy of vacant territories (Coates *et al.* 2007). Mortality of Common Ravens was probably under-reported in the Ontario studies because feeding activity was reported at some baits where no dead birds were observed (e.g., Linklater 1959, 1960), yet these birds likely perished. In one study, Linklater (1960: 5) concluded that "although no direct evidence of mortality in either animals or birds was found, it is felt that the ravens eventually succumbed to the poison". However, some of these Kenora studies used Compound 1080 rather than strychnine, and the former is known to be less toxic overall to birds (Connolly 2004) so there actually may have been lower raven mortality.

In contrast to Common Ravens, Canada Jays were reported as non-target mortality only in one study (at Rainy River; Chrysler 1960) although both species are distributed throughout northern Ontario and frequently feed on carrion in winter (Strickland and Ouellet 2020). Canada Jays cache food by removing pieces of carrion to be stored in trees and eaten later or fed to young (Strickland and Ouellet 2020). Kills of Canada Jays would be undiscovered if the bait is not consumed immediately and birds die after eating pieces of cached food away from the bait site, and the mortality was likely much higher than that observed.

Although Common Raven was the most common bird killed during the poisoning programs reported here, several other species of resident or early spring migrant species were also affected, principally Herring Gull, American Crow, Bald Eagle, and various woodpeckers. In contrast, in a recent wolf control study in Alberta, only 4% of birds killed were species other than Common Raven (one each of Bald Eagle, Golden Eagle [*Aquila chrysaetos*], and Canada Jay; Alberta Environment and Parks 2017). Breeding populations of Bald Eagles in northern Ontario were already depressed from the effects of dichloro-diphenyl-trichloroethane (DDT) in the 1950s and 1960s (Grier 1982), and incidental poisoning of Bald Eagle

may have had an additive impact. This could be particularly so as the poisoning occurred in late winter (mid-February to late-April) when the migrant adults would have just arrived back on territory and food resources would have been limited (Armstrong 2014). A study of Bald Eagle museum specimens with a known cause of death collected from Ontario and four other North American jurisdictions (November to May, 1900 to 1980) revealed four of 21 specimens (19%) that were poisoned incidentally by strychnine from canid control programs (Bortolotti 1984). In western Canada, Bald Eagle continue to suffer incidental poisoning of an unknown magnitude as a result of the ongoing illegal poisoning of Coyote using anticholinesterase pesticides (Wobeser *et al.* 2004).

Red Fox was by far the most common mammal to be killed by poisoning (77%). In a recent western Canada study, Red Fox and Coyote were similarly the most common non-target mammals killed (42% and 45%, respectively; Alberta Environment and Parks 2017). Several other mammalian species were also killed incidentally in the Alberta study, but all at relatively low detection rates. There may also have been population-level impacts on non-target predators such as Fisher (*Pekania pennanti*; Proulx *et al.* 2015) and Wolverine (*Gulo gulo*; Slough 2007; COSEWIC 2014).

Conclusions

The projects we have described provide the only known documentation of wolf poisoning programs in Ontario. Although completed over 50 years ago, they provide some context for current discussions on the ecological impacts and ethics of the use of poison to control wolves (Musiani and Paquet 2004; Proulx *et al.* 2015). They also provide valuable context for the evaluation of past ecological effects on non-target species.

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Literature Cited

Alberta Environment and Parks. 2017. Freedom of information and protection of privacy request for records pertaining to the "use of strychnine to control wolf populations in relation to Alberta's caribou recovery programs". Alberta Environment and Parks, Edmonton, Alberta, Canada.

Allen, G.T., J.K. Veatch, R.K. Stroud, C.G. Vendel, R.H. Poppenga, L.Thompson, J.A. Shafer, and W.E. Braselton. 1996. Winter poisoning of coyotes and raptors with furadan-laced carcass baits. Journal of Wildlife Diseases 32: 385–389. https://doi.org/10.7589/0090-3558-32.2.385

Anonymous. 1912. Final Report of the Ontario Game and Fisheries Commission 1909–1911. Legislative Assembly of Ontario. Accessed 25 November 2020. https://www.biodiversitylibrary.org/page/21164129.

Armstrong, T. (E.R.). 2014. Management Plan for the Bald Eagle (*Haliaeetus leucocephalus*) in Ontario. Ontario Management Plan Series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario, Canada.

Atkinson, G.E. 1894. A summer's collecting and observations at Port Arthur, Ontario. Biological Review of Ontario 1: 94–101.

Baillie, J.L., and C.E. Hope. 1943. The Summer Birds of the Northeast Shore of Lake Superior, Ontario. Contributions of the Royal Ontario Museum of Zoology 23, University of Toronto Press, Toronto, Ontario, Canada. https://doi.org/10.5962/bhl.title.52180

Beasom, S.L. 1974. Selectivity of predator control techniques in South Texas. Journal of Wildlife Management 38: 837–844. http://doi.org/10.2307/3800053

Bjorge, R.R., and J.R. Gunson. 1985. Evaluation of wolf control to reduce cattle predation in Alberta. Journal of Range Management 38: 483–486. https://doi.org/10.2307/3899736

Blomme, C. 1987. Common Raven. Pages 290–291 *in* Atlas of the Breeding Birds of Ontario. *Edited by* M.D. Cadman, P.F.J. Eagles, and F.M. Helleiner. University of Waterloo Press, Waterloo, Ontario, Canada.

Boarman, W.I., and B. Heinrich. 2020.Common Raven (*Corvus corax*), Version 1.0. *In* Birds of the World. *Edited by* S.M. Billerman. Cornell Lab of Ornithology, Ithaca, New York, USA. https://doi.org/10.2173/bow.comrav.01

Bortolotti, G.R. 1984. Trap and poison mortality of golden and bald eagles. Journal of Wildlife Management 48: 1173–1179. https://doi.org/10.2307/3801778

Carbyn, L.N., S.M. Oosenbrug, and D.W. Anions. 1993. Wolves, Bison and the Dynamics Related to the Peace-Athabasca Delta in Canada's Wood Buffalo National Park. Circumpolar Research Series Number 4. Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta, Canada.

Chrysler, B.A. 1960. Report on wolf poisoning project, Rainy River District, Feb. to Apr. 1960. Unpublished report. Ontario Department of Lands and Forests, Rainy River, Ontario, Canada.

Cluff, H.D., and D.L. Murray. 1995. Review of wolf control methods in North America. Pages 491–504 *in* Ecology and Conservation of Wolves in a Changing World. *Edited by* L.N. Carbyn, S.H. Fritts, and D.R. Seip. University of Alberta Press, Edmonton, Alberta, Canada.

Coates, P.S., J.O. Spencer, Jr., and D.J. Delehanty. 2007. Efficacy of CPTH-treated egg baits for removing ravens.

Human-Wildlife Interactions 1: 224–234. https://doi.org/10.26077/z6rq-zs30

Connolly, G.E. 2004. Development and use of compound 1080 in Coyote control, 1944–1972. Pages 221–239 *in* Proceedings of the 21st Vertebrate Pest Conference. *Edited by* R.M. Timm and W.P. Gorenzel. University of California, Davis, Davis, California, USA.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2014. COSEWIC assessment and status report on the Wolverine *Gulo gulo* in Canada. COSEWIC, Ottawa, Ontario, Canada.

Crins, W.J., P.A. Gray, P.W.C. Uhlig, and M.C. Wester. 2009. The Ecosystems of Ontario, Part I: Ecozones and Ecoregions. Inventory, Monitoring and Assessment, SIB TER IMA TR-01. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

D'Agostini, D. 1958. Wolf poisoning project, Port Arthur District, 1956–1957. Unpublished report. Ontario Department of Lands and Forests, Port Arthur, Ontario, Canada.

Dear, L.S. 1940. Breeding birds of the region of Thunder Bay, Lake Superior, Ontario. Transactions of the Royal Canadian Institute 49: 119–143.

Dymond, J.R., L.L. Snyder, and E.B.S. Logier. 1928. No. 1: a faunal survey of the Lake Nipigon Region, Ontario. Transactions of the Royal Canadian Institute 16: 233–291.

Grier, J.W. 1982. Ban of DDT and subsequent recovery of reproduction in Bald Eagles. Science 218: 1232–1235. https://doi.org/10.1126/science.7146905

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. https://doi.org/10.1139/cjz-2014-0142

Kolenosky, G.B., D.R. Voigt, and R.O. Standfield. 1978. Wolves and Coyotes in Ontario. Ontario Ministry of Natural Resources, Wildlife Branch, Toronto, Ontario, Canada.

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. *Edited by* L.N. Carbyn. Canadian Wildlife Service Report Series No. 45. Edmonton, Alberta, Canada.

Linklater, M. 1956. Experimental wolf poisoning program Kenora District. Unpublished presentation for the Port Arthur Fur Advisory Committee Meeting, April 26–28 1956. Ontario Department of Lands and Forests, Kenora, Ontario, Canada.

Linklater, M. 1959. Wolf poisoning experiment, Kenora District, 1959. Fish and Wildlife Management Report 48. Ontario Department of Lands and Forests, Maple, Ontario, Canada.

Linklater, M. 1960. Wolf poisoning experiment—Kenora District 1959–1960. Unpublished report. Ontario Department of Lands and Forests, Kenora, Ontario, Canada.

Linklater, M. 1961. Experimental wolf poisoning program—Kenora District 1961. Unpublished report. Ontario Department of Lands and Forests, Kenora, Ontario, Canada.

Loughry, A.G. 1958. Predator control in northern Canada. 1957–1958. Unpublished report. Canadian Wildlife Service, Ottawa, Ontario, Canada.

McKeown, W.J. 1959. Wolf poisoning project—Port Arthur District, west side 1959. Fish and Wildlife Management Report 48. Ontario Department of Lands and Forests, Maple, Ontario, Canada.

Musiani, M., and P.C. Paquet. 2004. The practices of wolf persecution, protection, and restoration in Canada and the United States. Bioscience 54: 50–60. https://doi.org/10.1641/0006-3568(2004)054[0050:tpowpp]2.0.co;2

Naughton, D. 2012. The Natural History of Canadian Mammals. Canadian Museum of Nature and University of Toronto Press, Toronto, Ontario, Canada. https://doi.org/10.3138/9781442669574

Omand, D.N. 1950. The bounty system in Ontario. Journal of Wildlife Management 14: 425–434. https://doi.org/10.2307/3797272

Ontario Ministry of Natural Resources. 2005. Backgrounder on Wolf Conservation in Ontario—Wolf Conservation Approaches, Legislation and Policy Affecting Wolves. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

Ontario Ministry of Natural Resources. 2013. Moose Resource Report. Wildlife Management Unit 16B. Queen's Printer for Ontario, Toronto, Ontario, Canada.

Ontario Ministry of Natural Resources and Bowater Canadian Forest Products Incorporated. 2008. Forest Management Plan for the Caribou Forest 2008–2018. Accessed 24 November 2018. https://nrip.mnr.gov.on.ca/s/fmp-online?language=en_US.

Pimlott, D.H. 1961. Wolf control in Ontario past, present and future. *In* Transactions of the 25th Federal-Provincial Wildlife Conference. Canadian Wildlife Service, Ottawa, Ontario, Canada.

Pimlott, D.H., J.A. Shannon, and G.B. Kolenosky. 1969. The Ecology of the Timber Wolf in Algonquin Provincial Park. Fish and Wildlife Research Branch Report No. 87. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

Pimlott D.H., J.A. Shannon, W.J. McKeown, and D. Sayers. 1961. Experimental Timber Wolf poisoning program in northwestern Ontario. Wildlife File Report 66. Ontario Department of Lands and Forests, Research Branch, Maple, Ontario, Canada.

Proulx, G., R.K. Brook, M. Cattet, and P. Paquet. 2015. Poisoning wolves with strychnine is unacceptable in experimental studies and conservation programmes. Environmental Conservation 43: 1–2. https://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.

Sayers, J.D. 1959. Wolf project for Sioux Lookout District, 1959. Fish and Wildlife Management Report 48. Ontario Department of Lands and Forests, Maple, Ontario, Canada.

Shannon, J.A., J.L. Lessard, and W. McKeown. 1962. Experimental Timber Wolf poisoning program in northwestern Ontario, 1961–62. Unpublished report. Ontario Department of Lands and Forests, Research Branch, Maple, Ontario, Canada.

Shannon, J.A., J.L. Lessard, and W. McKeown. 1963. Experimental Timber Wolf poisoning program in north-

western Ontario, 1962–63. Ontario Department of Lands and Forests, Research Branch, Maple, Ontario, Canada.

Shannon, J.A., J.L. Lessard, and W. McKeown. 1964. Experimental Timber Wolf poisoning program in northwestern Ontario, 1963–64. Ontario Department of Lands and Forests, Research Branch, Maple, Ontario, Canada.

Shannon, J.A., D. Sayers, and W. McKeown. 1961. Experimental Timber Wolf poisoning program in northwestern Ontario, 1960–61. Unpublished report. Ontario Department of Lands and Forests, Research Branch, Maple, Ontario, Canada.

Slough, B.G. 2007. Status of the wolverine *Gulo gulo* in Canada. Wildlife Biology 13 (Supplement 2): 76–82. https://doi.org/10.2981/0909-6396(2007)13[76:sotwgg]2.0.co;2

Snyder, L. 1953. Summer birds of western Ontario. Transactions of the Royal Canadian Institute 30: 47–95.

Stahler, D., B. Heinrich, and D. Smith. 2002. Common ravens, *Corvus corax*, preferentially associate with grey wolves, *Canis lupus*, as a foraging strategy in winter. Animal Behaviour 64: 283–290. https://doi.org/10.1006/anbe.2002.3047

Strickland, D., and H.R. Ouellet. 2020. Canada Jay (*Perisoreus canadensis*), Version 1.0. *In* Birds of the World. *Edited by* P.G. Rodewald. Cornell Lab of Ornithology, Ithaca, New York, USA. https://doi.org/10.2173/bow.gryjay.01

Swift, E.J. 1959. Wolf poisoning project, Port Arthur District, east side, 1959. Fish and Wildlife Management Report 48. Ontario Department of Lands and Forests, Maple, Ontario, Canada.

Theberge, J.B. 1973. Wolf management in Canada through a decade of change. Pages 89–102 *in* Proceedings of the First Working Group of Wolf Specialists and of the First International Conference on the Conservation of the Wolf. *Edited by* D.H. Pimlott. IUCN Publications, New York, New York, USA.

Turner, B. 1959. A wolf poisoning attempt, Gogama District, 1959. Unpublished report. Ontario Department of Lands and Forests, Gogama, Ontario, Canada.

Vyas, N.B. 1999. Factors influencing estimation of pesticide-related wildlife mortality. Toxicology and Industrial Health 15: 187–192. https://doi.org/10.1177/074823379901500116

Wobeser, G., T. Bollinger, F.A. Leighton, B. Blakley, and P. Mineau. 2004. Secondary poisoning of eagles following intentional poisoning of coyotes with anticholinesterase pesticides in western Canada. Journal of Wildlife Diseases 40: 163–172. https://doi.org/10.7589/0090-3558-40.2.163

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