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STUDY TO GATHER INFORMATION ON USES OF LEAD AMMUNITION AND THEIR NON-LEAD ALTERNATIVES IN NON-MILITARY ACTIVITIES IN CANADA

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List of Acronyms

AB	Alberta
AEWA	African-Eurasian Migratory Waterbirds Agreement
ALAD	Aminolevulinate dehydratase
BAU	Business as usual
BC	British Columbia
BCWF	British Columbia Wildlife Federation
BLL	Blood lead levels
BMP	Best Management Practices
CBSA	Canada Border Services Agency
CCC	Canadian Company Capabilities
CDC	Centers for Disease Control
CEPA	Canadian Environmental Protection Act (CEPA, 1999)
CHMS	Canadian Health Measures Survey
CID	Canadian Importers Database
CIMT	Canadian International Merchandise Trade Database
CMP	Chemical Management Plan
CMS	Convention on Migratory Species
CSC	Correctional Services Canada
CSSA	Canadian Shooting Sports Association
CWS	Canadian Wildlife Service
EC	European Commission
ECB	European Chemicals Bureau
ECCC	Environment and Climate Change Canada
EU	European Union
FMJ	Full Metal Jacket
Ga.	Gauge
HG	Handgun
HQS	Harvest Questionnaire
HS	Industry Canada harmonized system import codes
ILA	International Lead Association
IWS	Institute of Wildlife Studies
JHP	Jacketed Hollow Point
JI	Norwegian Association of Hunters and Anglers
LAB	Labrador
LIA	Lead Industry Association

LR	Long rifle
MB	Manitoba
MGBHP	Migratory Bird Hunting Permit
MNE	Multi-National Enterprise
NAICS	North American Industry Classification System
NB	New Brunswick
Nes	Not elsewhere specified
NFLD	Newfoundland
NHS	National Harvest Survey
NRA	National Rifle Association
NRCan	Natural Resources Canada
NS	Nova Scotia
NSSF	National Shooting Sports Foundation
NWT	Northwest Territories
NU	Nunavut
OECD	Organisation of Economic Cooperation and Development
OFAH	Ontario Federation of Hunters and Anglers
PAL	Possession and Acquisition Licence
POL	Possession only licence
Pb	Lead
PEI	Prince Edward Island
PHO	Public Health Ontario
PSL	Priority Substances List
PWGSC	Public Works Government Services Canada
QC	Quebec
RCC	Retail Council of Canada
RCMP	Royal Canadian Mounted Police
RI	Rifle
RMO	Risk Management Objective
RMS	Risk Management Strategy
SCS	Species Composition Survey
SDS	Safety Data Sheet
SG	Shotgun
SK	Saskatchewan
SME	Small to Medium-Sized Enterprise
SoC	Substances of Concern
TSMP	Toxic Substances Management Policy

UNEP	United Nations Environment Program
US EPA	US Environmental Protection Agency
YT	Yukon

1.0 Introduction

1.1 Background

Lead (Pb) is a soft, bluish metallic element mined from rock and it occurs naturally in the environment all over the world (e.g. in bedrock, soils, sediments, surface waters, groundwater and seawater). Lead also occurs naturally at low levels in foods (e.g. via uptake from soils by plants; subsequent consumption of plants by animals; and via uptake of water and sediments by fish).

An assessment of the most current science on lead was recently conducted and consolidated in a 'State of the Science' Report (Health Canada, Feb 2013[1]). The current Canadian blood lead intervention level is 10 µg/dL. However, since the establishment of that blood lead intervention level, scientific evidence has been published that demonstrates critical health effects occur below 10 µg/dL.[2] The risks associated with lead include developmental neurotoxicity, neurodegenerative, cardiovascular, renal and reproductive effects. Environmental risks include toxicity to wildlife. The Government of Canada therefore developed a Risk Management Strategy (RMS) for lead that outlines actions to further reduce risks associated with exposure to lead. The overall risk management objective (RMO) is to reduce exposure to lead to the greatest extent practicable by strengthening current efforts in priority areas where the government can have the greatest impact upon exposure of Canadians.

Canadians are exposed to low levels of lead via various routes including; food, drinking water, air, dust, soil, and lead-containing products. Although blood lead levels (BLLs) have declined by over 70% in Canada since 1978–1979, lead is still widely detected in the Canadian population. BLLs tend to rise after infancy, peak between 18 and 36 months, and decline slightly during childhood and adolescence before rising again with age. For example, the 2007–2009 Canadian Health Measures Survey (CHMS) data indicate that the mean BLLs for 6–11-year-olds are 0.90 µg/dL and 0.80, 1.12, 1.60, and 2.08 µg/dL for the age groups of 12-19, 20-39, 40-59, and 60-79 years, respectively. In addition, environmental releases of lead from continued use of lead products and resultant potential for toxicity to wildlife remain a concern.

Several sources of potential lead exposure of the general population and the environment remain a concern and require further analyses. This study is focused on the uses of lead in ammunition. Data on lead ammunition uses in Canada were gathered previously and indicated that, at that time, over 1,000 tonnes of lead were being released to land in Canada annually from the use of lead shot and bullets.[3] These data were gathered in the 1990s and required updating. It should be noted that the deleterious impacts of spent ammunition on wildlife have been well documented. In addition, it has been noted that many tens of thousands of tonnes of metallic lead shot and lead bullets are released into the global environment each year by recreational hunters and shooters. The vast majority of this ammunition is never reclaimed[4].

Most ammunition used in Canada is imported, primarily from US manufacturers. Smaller amounts of ammunition are manufactured in Canada or imported from other countries. The supply chain includes importers, distributors, and retailers (including traditional store-fronts such as big box stores, outfitters, gun and sporting goods shops, as well as online retailers). Ammunition can be distributed and sold by these retailers but also via gun clubs, shooting ranges and at shooting events, etc. End users include recreational shooters and hunters.

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[1] Health Canada. State of the Science Report on Lead. Final Report: February 2013

[2] For example, see: Dribben *et al*., 2011 Low level lead exposure triggers neuronal apoptosis in the developing mouse brain. Neurotoxicol. Tetratol. 33: 473-480; Gould, E. 2009. Childhood lead poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control. Environmental Health Perspectives 117: 1162-1167; Lanphear *et al*. 2005. Low-level environmental lead exposure and children's intellectual function: An international pooled analysis. Environ. Health. Perspect. 113: 894-899; Lucchini *et al*., 2012. Inverse association of intellectual function with very low blood lead but not with manganese exposure in Italian adolescents. Environ. Res. 118: 65-71

[3] Scheuhammer and Norris, 1995. A review of the environmental impacts of lead shotshell ammunition and lead fishing weights in Canada. Occasional Paper Number 88, Canadian Wildlife Service.

[4] As reviewed by V.G. Thomas & Guitart R. 2016. Environmental Policy and Law 46/2: 127-131

Some shooting ranges recover some spent ammunition – and the recovered ammunition can be recycled/reused.

At this stage, an accurate and up to date picture of the current uses of lead ammunition in Canada, a complete supply chain analysis, a lifecycle analysis for lead in ammunition, and a review of current management measures in Canada and internationally is required in order to assist risk managers at ECCC in developing appropriate risk management measures for lead use in ammunition to achieve the RMO. In addition, any measures to reduce the use of lead in ammunition would require increased use of alternatives, hence it is also important to assess the availability and pros and cons of alternatives in terms of technical efficacy and relative health and environmental profiles amongst other factors.

1.2 Purpose of the study

The purpose of this study was to research and gather background and use pattern information on lead ammunition and its alternatives. The information and analysis provided in the report should assist risk managers in finalizing an effective risk management strategy for lead that includes appropriate actions that address the use of lead in this application.

1.3 Objectives of the study

The specific objectives of this study were as follows:

- Provide a profile of the Canadian lead ammunition supply chain as well as providing similar details on non-lead alternatives (excluding ammunition used in military activities)
- Identify and describe existing ammunition products found on the Canadian market by category (e.g. ammunition used in hunting, indoor/outdoor shooting activities, target shooting, trap/skeet shooting and sporting clay shooting) and determine and describe their non-lead alternatives (excluding military applications).
- Conduct a lifecycle analysis of lead used in ammunition in the Canadian market including provision of analysis of the quantities manufactured, imported, exported, sold, recovered and released. Provide projections for the future based on available data on future trends, anticipated growth, market knowledge and intelligence.
- Provide a comprehensive review of existing measures and management practices aimed at restricting the use of lead ammunition for recreational activities, preventing or minimizing the releases of lead from ammunition, and promoting the use of alternatives in Canada, the U.S. and other OECD countries. Analyze the pros and cons of the findings in a Canadian context.

This is the Final Report.

2.0 Canadian Ammunition Supply Chain

This section of the report provides details on the major manufacturers, importers and retailers involved in the ammunition supply chain in Canada (sections 2.1 to 2.4). In addition, details on the end users and the facilities that allow the use of ammunition on their sites are provided (sections 2.5). The waste management activities associated with sites using ammunition are also provided (section 2.6) as well as a list of the key associations/interest groups that represent the stakeholders involved in the supply chain (section 2.7).

In developing the profile of the ammunition supply chain in Canada we used the following sources:

- Publicly available data on stakeholders involved in the supply chain (e.g. company websites, market research studies, business profiles and directories)
- Available data on ammunition trade (e.g. from Industry Canada, Statistics Canada, Canada Border Services Agency)
- Scientific literature and other publications related to ammunition (e.g. peer-reviewed studies, other published studies, information from other jurisdictions, market research data etc.)
- Direct contact with other government agencies with data relevant to ammunition (e.g. RCMP, Natural Resources Canada)
- Direct contact with stakeholders at all levels of the supply chain requesting input, including surveys (e.g. survey questions were sent to manufacturers, importers, distributors, major retailers, and end users; the end user surveys included a set of questions sent to shooting range managers and an electronic survey to hunters/sports shooters).

Overall, we received very little information from stakeholders hence most of the analysis is based on publicly available data.

2.1 Manufacturers Profile

Global production of ammunition is dominated by industrialized mass manufacturing[5]. There is relatively little ammunition manufacturing activity in Canada. Most ammunition used in Canada is imported and >90% of imported ammunition comes from the US[6]. The majority of ammunition used in Canada is manufactured in the US by large multi-national corporations. Overall the US gun and ammunition manufacturing industry in the US includes about 400 companies with combined annual revenues of about $10 billion USD. Firearms and accessories account for about 60% of the revenues and ammunition accounts for about 40% of revenues. US ammunition manufacturers have gross profits of approximately 36%[7]. Revenues of US firearms and ammunition manufacturers are expected to grow at an annual compounded rate of 2% between 2016 and 2020.[8] In Canada, there appears to be only one significant ammunition manufacturer and this company specializes in military applications (General Dynamics Ordnance and Tactical Systems - Canada Inc (GD-OTS Canada)[9]. There is very little ammunition manufacturing in Canada for the non-military market – and this manufacturing activity is composed mainly of manufacture of projectiles for reloading (e.g. lead shot production) and the re-manufacturing/reloading of ammunition cartridges.

[5] The US Firearms Industry: Production and Supply. J. Brauer. Small Arms Survey, Graduate Institute of International Studies, Geneva 2013 http://www.smallarmssurvey.org/publications/by-region/americas.html

[6] NRCan (pers. comm., 10 Nov 2016): Explosives Regulatory Division, ESSB

[7] Small arms ammunition manufacturing industry in the US and its international trade (2011 edition). Research and Markets (research and markets.com) report summary.

[8] Gun and Ammunition Manufacturing 2016. First Research Industry Profile.

[9] Prior to 2007 there were two larger domestic manufacturers of ammunition specializing in the military/defence market (General Dynamics (GD-OTS) and SNC Industrial Technologies Inc). GD-OTS acquired SNC Industrial Technologies in 2007: http://www.prnewswire.com/news-releases/general-dynamics-completes-acquisition-of-snc-technologies-inc-53330067.html

Ammunition consists of the projectile (bullet or shot), case, primer, and propellant (gunpowder) – these components are manufactured separately and then assembled to form the final cartridge. Recent market research reports on the ammunition manufacturing industry state that 'bullets are usually made from lead or lead alloy' and non-jacketed bullets and slugs are produced by pouring molten lead into a mould[10]. Cases for rifle/handgun ammunition are usually made of brass, steel or aluminum, with brass being the most common. Shotgun cartridges are made of brass and polypropylene plastic. Primers are made from two pieces of metal that encase a small amount of impact-sensitive explosive material. Gunpowder can be made by the ammunition manufacturers or purchased from suppliers. Ammunition assembly is highly automated. In brief, primers are inserted into the cases, the case is then charged or filled with the correct amount of gunpowder, and the projectile(s) then inserted into the case. Some bullets can be jacketed with another metal to create performance traits, examples include; full-metal jacket (FMJ)[11], jacketed hollow point (JHP), and jacketed soft point (JSP). Ammunition is manufactured in runs, which are assigned lot codes that are printed on the ammunition's box and allow it to be inventoried and traced. Manufacturers routinely test fire ammunition to ensure safety and quality. If a performance issue is found, ammunition from that lot can be recalled[12].

Ammunition manufacturers sell to wholesale distributors, who in turn sell to retailers. Most sales are associated with big box retailers[13].

Lead shot is produced in Canada using a shot tower where molten lead is dropped from a height. The surface tension of the liquid pulls them into a shape that has the least surface area, which is a sphere. Shot is sold in bulk bags for reloading.

Remanufacturing/reloading cartridges involves the reuse of previously fired cases and reloading these with the other components including primer and propellant. The projectile reloaded can be previously used/recycled or can be newly produced Reloading companies are small, unautomated, and use bulk components to reload cartridges by hand.

The major US manufacturers that supply the Canadian ammunition market are: Olin Winchester, Vista Outdoor, Remington Arms, Hornady, and Kent Cartridge (see Table 1). Additional US, European, and other suppliers are summarized in Table 2.

In terms of domestic ammunition manufacturing for the non-military market in Canada, the largest lead shot manufacturer in Canada is Hummason Mfg Ltd (Ancaster, Ontario). Other companies manufacturing ammunition in Canada include Prairieshot Ltd (MB), Campro (QC), and Société d'Expansion Commerciale Libec Inc. (S.E.C.L (Libec) Inc which manufactures using the brand names of Challenger Ammunition (QC). There are also a number of small companies that remanufacture cartridges – these companies reload empty, used, or new cartridge cases allowing their reuse. All Canadian companies involved in manufacturing ammunition for non-military applications, including remanufacturing activities, are SMEs (see Table 3).

Previous studies on ammunition manufacturers have noted difficulties in obtaining information on ammunition production "due to the lack of transparency by many companies and countries about their potential and actual ammunition output."[14] Given the importance of US manufacturers in supplying the Canadian market it is important to note that a study on the US firearms industry highlighted "the paucity of credible data and the difficulty accessing it – this is true for both data pertaining to the market as a whole and individual companies"[15]. Hence, there are widely recognized difficulties in obtaining data from the ammunition and firearms manufacturing industry.

[10] Gun and Ammunition Manufacturing 2016. First Research Industry Profile
[11] Not allowed for hunting in Canada
[12] Gun and Ammunition Manufacturing 2016. First Research Industry Profile
[13] Ibid, and pers. comm. with large retailer in Canada
[14] Targeting ammunition – A primer. Small Arms Survey, Graduate Institute of International Studies, Geneva 2006 http://www.smallarmssurvey.org/publications/by-type/book-series/targeting-ammunition.html
[15] The US Firearms Industry: Production and Supply. J. Brauer. Small Arms Survey, Graduate Institute of International Studies, Geneva 2013 http://www.smallarmssurvey.org/publications/by-region/americas.html

Table. 1. Major US Ammunition Manufacturers Supplying the Canadian Market (all supply both lead and non-lead ammunition)

Company Name	Number of employees	Gross Annual Revenue (USD)	Notes
Vista Outdoor	>7000	$2.27 billion	Vista Outdoor is Manufacturer, Importer and Distributor - it owns multiple key US-based ammunition manufacturers including Federal Premium (incl. American Eagle), Savage Arms, CCI, Blazer ammunition, Speer, RCBS. Company also manufactures other outdoor products e.g. Bushnell brand products amongst others..
Olin Winchester	>3700	$1.7 billion	Parent company is Olin Corporation which is involved in various industrial sectors. .
Remington Outdoor Company, Inc	>3400	$932 million	Formerly known as 'The Freedom Group' family of companies incl. Remington Arms, Bushmaster, Advanced Armament, Marlin Firearms, H&R Firearms, Dakota Arms, Para USA, DPMS, Barnes Bullets) - .note see also Crosman Corporation / Gravel Agency - import for and represent Remington in Canada Sold by Cdn Tire, Cabelas and others..
Hornady Manufacturing Co.	No data (nd)	$140.5 million	Sold by Canadian Tire, Cabelas, other retailers. This company directed our request for information to the US National Sport Shooting Federation (NSSF)
Kent Cartridge (Kent Canada Holdings)	nd	$3.27 million	A new company division 'Kent Gamebore Corporation' was formed specifically to develop lead-free shot-cartridges. Production in the US, small sales office in Canada (4 people employed at this office in Canada)..

The above 5 US companies are expected to supply the bulk of shotgun and rifle ammunition sold in Canada. The brands of ammunition produced by these companies are widely available across Canada from the large retailers that supply the majority of the ammunition market, as well as from smaller retailers. It is not possible to quantify the amount of ammunition sold in Canada per year for all the above manufacturers as the information was not provided by 4 of the 5 manufacturers.

Although the majority of the ammunition market in Canada is expected to be controlled by the above 5 companies, there are a number of other US, European and other manufacturers that supply the market. The following table (see Table 2) provides a more comprehensive list of manufacturers that supply the Canadian ammunition market.

Table 2. List of US, European and other manufacturers that supply the Canadian ammunition market (alphabetical order)

Company Name	Number of employees	Gross Annual Revenue (USD)	Notes	Supplies lead	Supplies non-lead
Aguila Ammunition	nd	nd	Aguila Ammunition (gunshot) is manufactured in Cuernavaca, Morelos, Mexico, by Industrias Tecnos, S.A. de C.V. Sold by in Canada by: http://www.odellengineeringltd.com/ (O'Dell Engineering has dealers/retail outlets across Canada (http://www.odellengineeringltd.com/find-a-dealer.html)	✓	✓
Barnaul (Parent company: BSZ Holding Company)	nd	$8 million	Sold by SFRC in Canada (gunshot)	✓	✓
Bismuth Cartridge Company	nd	nd	Lead-free gunshot (bismuth)		✓
Black Hills Ammunition	50-100	$7.48 million	Sold in Canada by Wanstalls online (gunshot and bullets)	✓	✓
Browning North America (see Herstal Group)	2,700 worldwide; 250 (Browning Arms Company); 1,500 in Belgium (FN Herstal)	>$225 million (Browning Arms Company); FN Herstal 771 million euros in 2015 (>50% military sales)	Subsidiary of Belgian-based Herstal Group (gunshot)	✓	✓
CCI (Vista Outdoor)	7000	>$2 bill (Vista Outdoor)	Specializes in rimfire rifle ammunition	✓	✓
Clever SRL		>$1 million	Sold in Canada by Trigger Wholesale	✓	
Crosman Corporation	323	$11.7 million	Air gun ammunition primarily (lead pellets); products sold through Cabelas/Bass Pro shops and Canadian Tire	✓	✓
Dominion Arms		$0.4 million		✓	
ELEY Ammunition			Imported by Korth Group into Canada (gunshot)	✓	✓
Environ-Metal, Inc	<10	$1 mill - $2.5 mill	Product: HEVI-shot. Sold in Canada via Canadian Tire		✓

Company Name	Number of employees	Gross Annual Revenue (USD)	Notes	Supplies lead	Supplies non-lead
Federal Premium (Vista Outdoor)	7000	>$2 bill (Vista Outdoor - parent Co.)	Sold by Canadian Tire and others (gunshot)	✓	✓
Fiocchi Ammunition	MNE	$21 million	Corporate HQ in US in Ozark, Missouri; Sales office in Nevada (gunshot)	✓	✓
Gamo Outdoor USA, Inc.		$5 million	Gamo products imported into Canada by REDL (BC); also distributed by Northern Tackle (AB)	✓	✓
Herstal Group (FN Herstal-Browning)	2,700 worldwide; 250 (Browning Arms Company); 1,500 in Belgium (FN Herstal)	>$225 million (Browning Arms Company); FN Herstal 771 million euros in 2015 (>50% military sales)	Mainly firearms manufacturing. Manufactures ammunition for military, security and special forces worldwide (applications excluded from the study). Manufactures firearms for hunting and shooting.	✓	✓
Hornady Manufacturing Co.	Nd	$140.5 million	Sold by Canadian Tire, Cabelas and others (rifle ammunition)	✓	✓
Industrial Surquillo S.A.C	nd		Sold by Cabela's in US (unclear if sold to cdn customers). Lead pellets in bulk for reloading, sold in 25lb bags	✓	
International Cartridge Corporation (ICC Ammo)	29-50	$2.5 million to $5 million	All lead free products		✓
Kent Cartridge / Kent Gamebore Corporation / Kent Canada Holdings	4 in Canada	<$1 million sales in Canada (Total Kent-Gamebore sales $3.27 million)	Listed as major importer on CIMT (gunshot)	✓	✓
Nosler Ammunition (includes Safari Brand Ammunition)	201-500	$28.62 million	Also have lead-free rifle ammunition alternatives.	✓	✓
Olin Winchester parent Company is	3773	$1.7 billion	Main distributor in Canada is Graywood (gunshot and rifle ammunition)	✓	✓

Company Name	Number of employees	Gross Annual Revenue (USD)	Notes	Supplies lead	Supplies non-lead
Olin Corporation					
PMC Ammunition	nd	nd	Sold in Canada by Target Sports Canada	✓	✓
Prvi Partizan A.D. (PPU)	>1000	>45 million euros in 2014	Distributed in Canada by Bell Lifestyle products. Sold by SFRC in Canada	✓	✓
Remington Outdoor Company, Inc. (ROC)	>3400	$931.9 million	(formerly known as 'The Freedom Group' family of companies incl. Remington Arms, Bushmaster, Advanced Armament, Marlin Firearms, H&R Firearms, Dakota Arms, Para USA, DPMS, Barnes Bullets). Note see also Crosman Corporation / Gravel Agency - import for and represent Remington in Canada Sold by Cdn Tire, Cabelas and others (shotgun and rifle ammunition)	✓	✓
Rio Ammunition Inc. (Parent Co: Maxam Outdoor)	Nd	$10.8 million	Lead and lead-free (bismuth) (gunshot)	✓	✓
RUAG Ammotec, a RUAG Group Company (RUAG Holding AG includes RWS and Rottweil and Geco)	Nd	$1760 million (RUAG Holding AG)	US facility established 2009 in Tampa. Now manufactures in 5 countries.	✓	✓
Sako Limited (a Beretta Group Company: Subsidiary of Beretta Holdings)	nd	$117 million (Beretta USA)	Sold by Cabela's and others in Canada; Canadian distributor for Sako is Stoeger Canada Ltd. Sako and Stoeger are part of international group Beretta Holdings	✓	✓
Savage Arms (Vista Outdoor)	7000	>$2 bill (Vista Outdoor); Savage Arms (Canada) Inc revenues: $12.16 million	Owned by Vista Outdoor – owns companies that manufacture and supply firearms and ammunition. Savage Arms specializes in firearms.	✓	✓
Sellior & Bellot	nd	nd	Represented in Canada by North Sylva Co. – importer (rifle ammunition)	✓	✓
Stoeger Ammunition	nd	$117 million (Beretta USA)	Mfg in Germany, HQ in US for North American Sales. (Parent company: Benelli USA: Benelli is a Beretta Group Company: Subsidiary of Beretta	✓	✓

Company Name	Number of employees	Gross Annual Revenue (USD)	Notes	Supplies lead	Supplies non-lead
			Holdings)		
Superior Ammunition	nd	$0.13 million	Privately held company in Summerville, South Carolina USA	✓	
Vista Outdoor	7000	$2.27 bill	Vista Outdoor is Manufacturer, Importer and Distributor - it owns multiple key US-based ammunition manufacturers including Federal Premium (incl. American Eagle), Savage Arms, CCI, Blazer ammunition, Speer, RCBS - are owned by Vista Outdoors. Company also manufactures other outdoor products e.g. Bushnell amongst others (shotgun and rifle ammunition)	✓	✓
Weatherby Inc.	nd	$36 million	Sold in Canada by Cabelas, others (rifle ammunition)	✓	

The following table summarizes details of the companies involved in the domestic manufacture of ammunition and ammunition components (see Table 3).

Table 3: Ammunition Manufacturers in Canada

Company Name	Notes on supply chain role(s)	Number Employees	Gross Annual Revenue	Street	City	Province	Ammunition manufactured in Canada	Supplies Lead	Supplies Non-lead
Campro	Manufacture copper-plated lead bullets. Owned by Metoplus	20	SME	47, rue de Rotterdam	St-Augustin-de-Desmaures	QC	Technical information of the Campro website indicates that they specialize in the manufacture of copper-plated lead bullets: Bullets: Full copper plated 0.008" (203 µm) thick copper layer. Allows the safe use of magnum loads. Composed of 98% lead and 2% antimony	✓	
Canadian BDX Inc.	Remanufactures cartridges / reloader - may be primarily a wholesaler: 423910, Sporting and Recreational Goods and Supplies Merchant Wholesalers	1	<$180K	Box 187	Black Diamond	AB	Sold by Canada's Best Sporting Goods 385 Bloor Street West, Oshawa, Ontario 905-725-5798 / Gagnon Sports. Note on website: "CAUTION, Exposure to Lead can be Hazardous to your health, Youth's and pregnant women, are more susceptible to health hazards so extra caution must be utilized. Limited use on Indoor Facility is recommended, good hygiene, Lead Free Ammunition, etc. are some ways to safeguard from excessive exposure. Most firearms shooting has some form of Lead Hazard, and the user is urged to make himself/herself familiar with safe guidelines. Both Primers and Bullets contain lead. "	✓	✓
Canadian Superior Munitions	Used to manufacture lead shot in Canada (Scheuhammer & Norris 1996) but does not appear to be	n/a	No longer active	10731 180 St NW	Edmonton	AB	No evidence of current manufacturing activity for ammunition in Canada found		

	active now								
Custom Reloading Service Inc.	Imports reloading components and manufactures cartridges via reloading		SME	22625 124 Ave	Maple Ridge	BC	States that it is the largest importer of reloading components in Canada, largest commercial reloading service in Canada	✓	
Econocycle	Re-manufactures Cartridges, 30 Mm. and Below in Sainte-Julie, QC		SME	474 Rue Des Marguerites	Sainte-Julie	QC	Sell new and recycled cartridges	✓	
General Dynamics Ordnance and Tactical Systems - Canada Inc (GD-OTS Canada)	Manufactures cartridges at manufacturing facility in QC	1450 in Canada (>80,000 worldwide)	>$20 billion	5, montée des Arsenaux	Repentigny	Quebec	US Parent: General Dynamics is a prime military contractor to the Pentagon (the US government accounts for about 60% of sales). The company's military operations include information systems and technology (information technology and collection, as well as command control systems); marine systems (warships, commercial tankers, and nuclear submarines); and combat systems (battle tanks, wheeled combat/tactical vehicles, munitions, and rockets and gun systems).[16.] Seem to be mainly focused on military/defence. Has contracts/ supply agreements with DND via Buy&Sell. Bought SNC TEC (QC) in 2007: SNC TEC was a main supplier of ammunition used by the Canadian DND, and supplier of small-, medium- and large-caliber ammunition to the U.S. Defense Department amongst other jurisdictions.	✓	
Heart Energy	Remanufactures Cartridges, 30	1	SME	2838 Hastings	Vancouver	BC	Sell new and recycled cartridges	✓	

[16] http://www.hoovers.com/company-information/cs/company-profile.general_dynamics_corporation.cdfeede267030627.html

Cartridge Ltd (Save on Cartridge Plus)	Mm. and Below in Vancouver BC			Street East Suite 113					
Hummason Mfg Ltd	Manufactures lead shot in Canada and also distributes US-mfrd ammunition e.g. from Winchester	2	<$900,000	PO Box 81047, 623 Trinity Road	Ancaster	ON	Lead shot (operate lead shot tower)	✓	
MarsMetal	Minor production line for lead shot - used for variety of end-uses. Makes downrigger weights, other misc. lead products custom mfr.	15	$1-5 million	4140 Morris Dr	Burlington	ON	Manufactures variety of lead products including lead shot. Some may be used for ammunition.	✓	
Prairieshot Ltd	Mfr lead and steel shot and shot cartridges	<5	$776,000	108- 4th Ave., PO Box 595	Carberry	MB	Mfr with lead and steel. "SCORE cartridges are proudly manufactured in Carberry, Manitoba Canada. They are assembled using only the finest brass hulls and quality lead and steel. "	✓	✓
Société d'Expansion Commerciale Libec Inc. (S.E.C.L (Libec) Inc (Challenger Ammunition (Challenger Les Cartouches) / Imperial	Imports under 'SOCIETE D'EXPANSION COMMERCIALE LIBEC INC" (Challenger Ammunition)	15	$6.71 million for S.E.C. Libec Inc.	PO Box 120, 3250 Montée De La Station	Ste-Justine-de-Newton	QC	Produces shot cartridges, and firearms ammunition, including bullets, and centrefire and rimfire rounds. Manufactures lead shot and steel shot. Sell shooting and reloading supplies. Distributor of reloading components; distributors for Winchester, White Flyer Targets and Challenger Ammunitions. Importer of ammunition. Sold by Canadian Tire (Imperial brand) e.g. http://www.canadiantire.ca/en/pdp/imperial-12-gauge-2-75-in-ammunition-1-1-8-oz-	✓	✓

Ammunition))							1751893p.html#srp		
The Bullet Barn Mfg. Co.	Manufacturers of quality hard cast lead bullets made with virgin alloys for reloaders			4561 Sinclair Bay Road	Garden Bay	BC	Manufactures lead bullets for reloading	✓	
Wolf Bullets (1011653 Ontario Ltd.)	Projectiles: WOLF BULLETS has been involved in the manufacture of hard cast lead bullets for over 15 years.			PO Box 604	Kingston	ON	We cast our bullets from virgin alloy only. 92% lead - 6% Antimony - 2% Tin. Also distribute/ sell Winchester copper-jacketed bullets. Sell to Peel Regional Police - reload cartridges - remanufacture cartridges using customer supplied cases	✓	✓

The above Table 3 includes some companies that are remanufacturers / reloaders – as some remanufacturers appear to also manufacture the projectiles/lead shot that they use for re-loading. Some reloading companies buy the projectiles/shot used for reloading cartridges and then sell the reloaded cartridges. Some companies sell reloading supplies allowing individuals to reload their own cartridges. Table 4 provides a list of reloading companies in Canada.

Table 4. List of Companies in Canada that Reload/Remanufacture Cartridges and/or sell reloading supplies

Company	Reloading		Adress			
	Supplies	Ammo	Street	City	Prov	Postal Code
Banner Speciality Ltd.			1631 St Mary's Rd	Winnipeg	MB	R2N 1Z4
Bass Pro Shops (Ontario)	✓		1 Bass Pro Mills Drive	Vaughan	ON	L4K 5W4
Budget Shooter Supply		✓	8942 184th Street	Surrey	BC	V4N 3T3
Bullet Barn Mfg. Co.		✓	4561 Sinclair Bay Road	Garden Bay	BC	V0N 1S1
Bulls Eye London		✓	820 Wharncliffe Rd South - Unit 32	London	ON	N6J 2N4
Cabela's	✓		25 De Baets Street	Winnipeg	MB	R2J 4G5
Calibers Group	✓		1092 South Service Rd West	Oakville	ON	L6L 5T7
Canada Ammo		✓	103 Bowser Ave	North Vancouver	BC	V7P 3H1
Canadian BDX Inc.		✓	Box 187	Black Diamond	AB	T0L 0H0
Custom Reloading Service Inc.		✓	22625 124 Ave	Maple Ridge	BC	V2X 4J9
DJ Friesen Imports	✓			Chilliwack	BC	V2R 4B8
Ellwood Epps Sporting Goods	✓		9431 Hwy 11 North	Severn	ON	L3V 0Y8
Frontier Firearms and Army Surplus	✓	✓	930 6th Ave East	Prince Albert	SK	S6V 2J8
Granlund Firearms	✓		BOX 946 522 South Dogwood Unit # 7	Campbell River	BC	V9W 6Y4
Grouse River	✓		2600 Enterprise Way	Kelowna	BC	V1X 7Y5
Gun Shop - online store	✓					

Heart Energy Cartridge Ltd (Save on Cartridge Plus)	✓	✓	2838 Hastings Street East Suite 113	Vancouver	BC	V5K 5C5
Hummason Mfg. Ltd.	✓		P.O. Box 81047	Ancaster	ON	L9G 4X1
Independent Ammunition Manufacturing Ltd		✓		Gull Lake	SK	S0N 1A0
Les Industries Centaure Ltée		✓	1234 Avenue Godin	Laval	QC	H7E 2T2
North Pro Sports - Performance Archery and Arms	✓		211 103 St E	Saskatoon	SK	S7N 1Y8
Northern Arms & Munitions		✓	500 Barrydowne Rd # 3	Sudbury	ON	P3A 3T3
OMA Products Ltd.		✓	PO Box 764 5321 Annaham Cres.	108 Mile Ranch	BC	V0K 2Z0
Reliable Gun Vancouver	✓		3227 Fraser Street	Vancouver	BC	V5V 4B8
Rusting Wood Trading Company	✓		34239 Hartman Avenue	Mission	BC	V2V 6B2
SFRC		✓	4567 Rd 38	Harrowsmith	ON	K0H1V0
Sportèque	✓		760 Boul St-Joseph	Drummondville	QC	J2C 2C3
Tenda Canada	✓	✓	75 W Beaver creek Unit10	Richmond Hill	ON	L4B 1K4
Tony Sport Enrg		✓	6556 Av Papineau	Montreal	QC	H2G 2X2
Wasp Munitions	✓	✓		Sylvan Lake	AB	T4N 6G5
Western Metal Inc.	✓	✓		Calgary	AB	
Wholesale Sports	✓		25 Heritage Meadows Way SE	Calgary	AB	T2H 0A7
Wolf Bullets		✓	P.O. Box 604	Kingston	ON	K7L 4X1
X-reload	✓		18435 Grand Rang Saint-François	St-Hyacinthe	QC	J2T 5H2

As stated earlier, most ammunition used in Canada is imported in the form of complete cartridges and most is manufactured in the US by large multinational companies (MNEs). The major US manufacturers that supply the Canadian market are Remington Outdoor, Vista Outdoor (brands include Federal Premium, CCI, Savage Arms, Blazer, Speer, RCBS), Olin Corporation (brands include Winchester), Hornady Manufacturing Company, and Kent Cartridge (Kent Gamebore). Smaller amounts of ammunition are supplied to Canada from smaller US firms, European manufacturers, and manufacturers from other jurisdictions. The major manufacturers of complete cartridges also manufacture and supply components for reloaders e.g. Hornady, Remington, Olin Winchester, and Vista Outdoor all sell projectiles for reloading.

The major ammunition manufacturers that supply the Canadian market were contacted for information on their ammunition sales to Canada with very little response. One major US-based manufacturer provided no data but re-directed our request to the US National Shooting Sports Foundation (NSSF) – the trade association for the firearms, ammunition, hunting and shooting sports industry. The NSSF has taken a strong position opposing any attempt to control the use of 'traditional' lead ammunition[17]. The NSSF replied to request for information stating "NSSF does not have precise data to answer your questions. It does not exist that we know of." (NSSF pers. comm. 8 Dec, 2016).

Overall, it appears that stakeholders in the ammunition market are extremely reluctant to provide data for a government study. Since most manufacturers that supply the Canadian market appear to be unwilling to provide information voluntarily ECCC could consider using section 71 of CEPA to ensure that comprehensive data are obtained from ammunition suppliers active in the Canadian market.

To give an example of the negative responses to the study and the requests for information the following posting by the Canadian Shooting Sports Association (CSSA) which was sent to all its members, and other stakeholders, on Dec 16, 2016 is provided for illustration:

[17] NSSF: The Facts on Lead Ammunition: http://nssf.org/factsheets/traditional-ammunition.cfm

Figure 1. CSSA Message sent out to stakeholders regarding this study

COMMENTARY: GATHERING AMMO INFORMATION TO ATTACK OUR RANGES

Environment Canada (EC) has commissioned a company in Vancouver called *"ToxEcology – Environmental Consulting Ltd"* to gather data regarding lead ammunition.

This is the second time they have launched this initiative. The intent is to gather data to be used by EC to ban the sale of all lead ammunition in Canada, despite the mountains of scientific evidence that shows lead on shooting ranges is not a problem.

THIS IS SERIOUS. Fabricated evidence against the use of lead ammunition has already resulted in the closure of shooting ranges and lead ammunition use in some regions of the world. Most harshly, it affects shotgunners and indoor ranges, despite existing safeguards that work.

Make no mistake on where this is coming from: this is being spearheaded by anti-hunting and anti-firearm groups around the globe.

And in giving ToxEcology data, you are giving them the information they will torque and spin to justify a grave attack on our community. Need some proof? How about the letter sent from ToxEcology to all "Range Managers" in Canada? Ever see a listing of Range Managers? Nope, because there is no public listing. The confidential information comes from the government through the CFOs that regulate ranges.

As stated earlier, EC began this assault a few years ago and at that time, the Harper government recognized it for what it was - a thinly veiled anti-gun attack - and shut it down.

But it's back.

This "study" can only have one purpose: to ignore the vast data amassed that prove lead on ranges is of no concern and to fabricate evidence that will be used to make shooting more difficult and far more expensive. Most American and Canadian manufacturers and distributors have soundly rejected cooperation with ToxEcology.

Say **NO** to this request.

From:http://myemail.constantcontact.com/Team-CSSA-E-News---December-16--2016.html?soid=1124731702303&aid=kcd8WQca-f0 http://cssa-cila.org/ Dated Dec 16, 2016

Note that Chief Firearms Officers (CFOs) did not provide confidential data or any contact details for range managers – all data used were obtained from public sources (e.g. range websites).

2.2 Importers Profile

Data on importers and imports were obtained from the Canadian Importers Database (CID), the Canadian International Merchandise Trade Database (CIMT), Canada Border Services Agency (CBSA), and Natural Resources Canada (NRCan). Industry Canada's CID provides some information on the identities of major importers based on imports under harmonized system (HS) import codes. Statistics Canada's CIMT provides information on the imports of specific products; again, these are based on imports categorized under HS codes. Additional data on imports can be obtained from CBSA on special request. NRCan was able to provide data on ammunition imports because ammunition cartridges are considered explosives under the *Explosives Regulations* and all imports must be reported to NRCan. The imports of ammunition cartridges reported to NRCan are categorized under a UN transportation code which is broad and does not distinguish between types of cartridges or their content.

As stated in Section 2.1 most ammunition used in Canada (excluding military applications) is imported into Canada. Some imports of ammunition can be tracked using harmonized system (HS) commodity codes.

Trade in ammunition is covered under the following HS commodity codes (see Table 5).

Table 5. HS Codes for Ammunition

HS Codes (with detail to 10-digit level)	**HS Description – Ammunition**
9306	Bombs, grenades torpedoes, mines, missiles and similar munitions of war and pars thereof; cartridges and other ammunition and projectiles and parts thereof, including shot and cartridge wads: shotgun cartridges and parts thereof; air gun pellets:
9306.21.00.00	Shotgun cartridges
9306.29.00.00	Air gun pellets
9306.29.10.00	Parts of shotgun cartridges
9306.29.90.00	Other shotgun cartridges, nes and parts thereof
9306.30	Other cartridges and parts thereof:
9306.30.41	Cartridges and empty cartridge shells
9306.30.41.10	Cartridges containing a projectiles: for rifles and pistols: .22 caliber
9306.30.41.20	Cartridges containing a projectiles: for rifles and pistols: other
9306.30.41.30	Cartridges containing a projectiles: other
9306.30.41.38	Cartridges for riveting or similar tools for captive-bolt humane killers and parts thereof
9306.30.41.40	Empty cartridge shells for rifles and pistols
9306.30.41.50	Empty cartridge shells: other
9306.30.41.60	Cartridges and empty cartridge shells: other
9306.30.80.00	Other cartridges and parts thereof: other
9306.90.00.00	Other parts of bombs, grenades, torpedoes, mines, missiles, other ammunition and projectiles
9306.90.00.20	Guided missiles
9306.90.00.40	Bombs, grenades, torpedoes, mines and similar munitions war; other ammunition and projectiles
9306.90.00.60	Parts for guided missiles

HS Codes (with detail to 10-digit level)	HS Description – Ammunition
9306.90.00.80	Parts for bombs, grenades, torpedoes, mines and similar munitions of war; parts of other ammunition and projectiles

The available HS codes most relevant to this study are highlighted in green in the table above. It should be noted that HS Codes cannot be used to identify imports of ammunition containing lead projectiles vs non-lead projectiles as the HS code import descriptions do not provide this level of detail.

These HS codes were used to gather publicly available information on ammunition imports from the Canadian International Trade Merchandise Database (CIMT) and to identify major importers (Canadian Importers Database (CID). The identities of the importers obtained from CID are provided in the following section along with information on market concentration for each HS Code.

Data were not available in CID or CIMT for all the highlighted codes. In addition, publicly available data from CID and CIMT are generally restricted to the 6-digit level. The relevant codes for which data were available in CID and CIMT were the following:

- 9306.21: Shotgun cartridges
- 9306.29: Air gun pellets and parts of shotgun cartridges
- 9306.30: Other cartridges and parts thereof

The publicly available data for the imports of these ammunition products are provided in the following sections.

2.2.1 Major Importers of Shotgun Cartridges (HS 930621)

The ten-digit HS code 9306.21.00.00 is specific for 'shotgun cartridges'. The Canadian Importers Database (CID) provides data on major importers only up to the 6-digit HS code level. The 6-digit HS code 930621 is listed by CID as providing data specific to 'Cartridges – For Shotguns'.[18] The data based on HS 930621 are therefore expected to be specific for imports of shotgun cartridges.

The major importers of shotgun cartridges are shown in Table 6.

[18] Industry Canada, CID: https://www.ic.gc.ca/app/scr/ic/sbms/cid/productReport.html?hsCode=930621

Table 6. Major Canadian Importers of Shotgun Cartridges (2014)

Major Canadian Importers (2014): Shotgun Cartridges HS 930621			
Company Name (alphabetical order)	**City**	**Province**	**Postal code**
KENT CARTRIDGE CANADA INC	Markham	Ontario	L3P 3P2
NORTH SYLVA CO DIVISION OF PARKLANDS MANOR INC	North York	Ontario	M6M 2L7
OLIN CHLOR ALKALI PRODUCTS (Olin Corporation)	Monrtéal	Québec	H3A 2A5
REDL SPORTS	Northbrook	Illinois	
REMINGTON ARMS COMPANY INC	Madison	North Carolina	
S.I.R. MAIL ORDER (Cabela's)	Winnipeg	Manitoba	R2C 4S2
UNIDENTIFIED IMPORTER			

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Three of the importers listed above are ammunition manufacturers with the ammunition being manufactured in the US and then imported into Canada (i.e. Kent Cartridge Canada Inc., Olin Corporation, Remington Arms Company Inc.). Two are distributors (i.e. North Sylva, REDL[19]) and one is a major retailer (Cabelas, importing under 'SIR Mail Order' which is the name of a company that no longer exists – a company that was bought years ago by Cabelas).

It should be noted that Olin Corporation is a very large multinational corporation active in various industry sectors. Olin Corporation has a Chlor Alkali and Vinyls production facility in Canada and, in this case, uses this facility as the importer of record to import at least some of its ammunition into Canada.

The following table shows available market concentration data for shotgun cartridge imports (see Table 7)

Table 7. Market Concentration for Shotgun Cartridges HS 930621

Market Concentration : Shotgun Cartridges HS 930621		
Number of Importers	**Value of Imports ($CDN)**	**Cumulative % of Imports**
3	15 754 051	60,15%
7	20 337 440	77,65%
All	26 192 616	100%

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Seven companies are responsible for >77% of shotgun cartridge imports into Canada. The total number of importers is not publicly available from CID.

2.2.1.1 Import Volumes for Shotgun Cartridges (HS 930621)

Available data on the quantity of imports were obtained from CIMT indicating that 90% of shotgun cartridge imports into Canada are from the US. CIMT does not provide the quantity of cartridges publicly for this HS Code so the value of imports can be used as a proxy to assess relative import quantities. Table 8 provides details on the value of shotgun cartridge imports for the period 2012-2015.

Table 8: Shotgun Cartridge Imports by Country 2012-2015 (HS 930621)

[19] REDL is listed as the importer of record in CID – note that REDL was acquired by Maurice Sporting Goods in 2011 (a major US-based distributor of sporting goods) – REDL/Maurice distribute to over 2000 storefronts in Canada, and ship to all 10 provinces and 3 territories: http://www.maurice.net/OurStory

Rank	Country	2015		2014		2013		2012	
		Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)
		Trade amount							
Total	World	0	23,791,502	0	25,788,216	0	19,491,017	0	19,852,824
1	United States	0	22,293,886	0	23,094,841	0	18,169,068	0	18,879,994
2	Italy	0	561,938	0	881,119	0	322,589	0	277,026
3	China	0	371,191	0	428,541	0	241,290	0	261,390
4	Russian Federation	0	159,443	0	155,619	0	0	0	0
5	France	0	120,756	0	232,536	0	0	0	50,194
6	Germany[1]	0	100,587	0	214,116	0	118,440	0	47,441
7	Spain	0	94,168	0	720,764	0	438,651	0	199,497
8	United Kingdom	0	39,938	0	50,815	0	166,793	0	127,163
9	Australia	0	29,585	0	7,012	0	20,083	0	6,236
10	Mexico	0	12,209	0	0	0	0	0	

Source: CIMT (Statistics Canada): http://www5.statcan.gc.ca/cimt-cicm/

There was an increase in the value of shotgun cartridge imports between 2012 and 2015 with the total value of imports increasing by almost 20% during this period.

In 2015, 21,842,143 shotgun cartridges (HS 9306.21.0000) with a total value of $18.6 million (USD) were exported from the US to Canada (National Shooting Sports Foundation, US, pers. comm. 07 Dec 2016). The average price per cartridge based on Canadian total import value for US imports from CIMT for 2015 ($22,293,886) and US export numbers (21,842,143 cartridges) indicates an average value per cartridge of C$1.02.

2.2.2 Major Importers of Air Gun Pellets and Parts of Shotgun Cartridges (HS 930629)

The ten-digit HS code 9306.29.00.00 is specific for 'air gun pellets' and HS 9306.29.90.00 covers 'other shotgun cartridges, nes,[20] and parts thereof'. The Canadian Importers Database (CID) provides data on major importers only up to the 6-digit HS code level and hence includes air gun pellets and other cartridges, nes, and parts thereof. Some products imported under 'other cartridges, nes, and parts thereof' are not relevant to this study as they can include cartridges without projectiles used to administer drugs into animals (e.g. Pneu-darts).

The major importers of air gun pellets are shown in Table 9.

[20] Not elsewhere specified

Table 9. Major Canadian Importers of Air Gun Pellets and Parts of Shotgun Cartridges (2014)

Major Canadian Importers (2014): Air Gun Pellets HS 930629			
Company Name (alphabetical order)	**City**	**Province**	**Postal Code**
CANADIAN TIRE CORPORATION , LIMITED	Brampton	Ontario	L6T 4L5
CROSMAN CORPORATION	East Bloomfield	New York	
PRAIRIE SHOT LTD.	Carberry	Manitoba	R0K 0H0
S.I.R. MAIL ORDER (Cabelas)	Winnipeg	Manitoba	R2C 4S2
SOCIETE D'EXPANSION CO MMERCIALE LIBEC INC (Challenger Ammunition)	Sainte-Justine-de-Newton	Quebec	J0P 1T0
TARGET CATTLE CONCEPTS	Minton	Saskatchewan	S0C 1T0

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Three of the importers listed above are ammunition manufacturers i.e. Crosman Corporation Ltd (US manufacturer of air gun pellets), Prairieshot Ltd. (Canadian Shot Manufacturer), and Societe d'Expansion Commerciale Libec Inc. / Challenger Ammunition (Canadian Ammunition Manufacturer). One of the major importer is a major retailer of ammunition i.e. Canadian Tire Corporation Ltd. The cartridges imported by Target Cattle Concepts are used to fire darts into animals to deliver drugs/medications (Pneu-darts)[21] – these cartridges are not relevant to this study.

The following table shows available market concentration data for air gun pellet imports (see Table 10)

Table 10. Market Concentration for Air Gun Pellets and Parts of Shotgun Cartridges HS 930629 (2014)

Market Concentration: Air Gun Pellets HS 930629		
Number of Importers	**Value of Imports ($CDN)**	**Cumulative % of Imports**
3	5,264,475	68.10%
6	6,190,451	80.08%
All	**7,730,785**	**100.00%**

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Six companies are responsible for >80% of air gun pellet imports into Canada. The total number of importers is not publicly available from CID.

[21] http://www.pneudart.com/

2.2.2.1 Import Volumes for Air Gun Pellet s and Parts of Shotgun Cartridges (HS 930629)

Available data on the quantity of imports were obtained from CIMT indicating that air gun pellets and parts of shotgun cartridges are imported from various countries. CIMT does not provide the quantity of air gun pellets or cartridges publicly for this HS Code so the value of imports can be used as a proxy to assess relative import quantities. Table 11 provides details on the value of air gun pellets and parts of shotgun cartridges imports for the period 2012-2015.

Table 11: Air Gun Pellets and Parts of Shotgun Cartridges Imports by Country of Origin 2012-2015 (HS 930629)

Rank	Country	2015		2014		2013		2012	
		Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)
		Trade amount							
Total	World	0	20,450,904	0	7,694,476	0	5,784,920	0	5,149,222
1	United States	0	13,337,527	0	2,157,093	0	1,805,347	0	2,720,808
2	Turkey	0	2,355,805	0	27,925	0	4,588	0	2,726
3	France	0	1,878,838	0	1,309,628	0	942,637	0	168,448
4	China	0	714,415	0	540,120	0	601,612	0	763,757
5	Taiwan	0	548,342	0	338,590	0	332,437	0	438,791
6	Italy	0	459,023	0	2,306,999	0	1,445,864	0	109,703
7	Spain	0	348,226	0	404,669	0	137,618	0	114,439
8	Germany	0	278,854	0	263,443	0	167,186	0	294,273
9	Korea, South	0	181,832	0	23,870	0	16,322	0	5,951
10	Russian Federation	0	67,260	0	0	0	0	0	0

Source: CIMT (Statistics Canada): http://www5.statcan.gc.ca/cimt-cicm/

There was an increase in the value of air gun pellets and parts of shotgun cartridges imports between 2012 and 2015 with the total value of imports increasing substantially between 2014 and 2015. The majority of imports in 2015 (>65%) came from the US.

2.2.3 Major Importers of Ammunition Cartridges, Nes and parts thereof (HS 930630)

The 6-digit HS Code 9306.30 'Other cartridges, nes, and parts thereof' includes a number of sub-codes that are relevant to this study and some sub-codes that are not relevant to this study. For example, the following sub-codes are relevant to the study:

HS 9306.30.90 'Other cartridges':

- 9306.30.90.12: Centrefire ammunition cartridges
- 9306.30.90.24: Bullets

The following sub-code covers products not expected to be relevant to this study:

- 9306.30.10.00: Poisonous cartridges for apparatus for the destruction of predatory animals / starter cartridges for diesel or semi-diesel engines / two shot cartridges designed for bird scaring devices.

In addition, several sub-codes under HS 9306.30 are very general e.g. the product description for 9306.30.90.19 is 'Other cartridges; other' and the product description for HS 9306.30.90.29 is 'Parts of cartridges, other'. Hence, it is difficult to pin-down the exact products that may be being imported under these sub-codes.

The major importers of ammunition cartridges (nes and parts thereof) are shown in Table 12.

Table 12. Major Canadian Importers of Ammunition Cartridges, nes and parts thereof (2014)

Major Canadian Importers (2014): Cartridges, nes and parts thereof HS 930630			
Company Name (alphabetical order)	**City**	**Province**	**Postal Code**
GENERAL DYNAMICS ORDNANCE AND TACTICAL SYSTEMS - CANADA INC.	Le Gardeur	Quebec	J5Z 2P4
HILTI (CANADA) CORPORATION	Mississauga	Ontario	L5N 6S2
HUMAN RESOURCES AND SOCIAL DEVELOPMENT CANADA	Gatineau	Quebec	K1A 0J9
KORTH GROUP LTD.	Okotoks	Alberta	T1S 1A7
NORTH SYLVA CO DIVISION OF PARKLANDS MANOR INC	North York	Ontario	M6M 2L7
OLIN CHLOR ALKALI PRODUCTS	Montréal	Quebec	H3A 2A5
OLIN CORPORATION WINCHESTER DIVISION	East Alton	Illinois	
REMINGTON ARMS COMPANY INC	Madison	North Carolina	
S.I.R. MAIL ORDER (Cabelas)	Winnipeg	Manitoba	R2C 4S2

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Three of the importers listed above are ammunition manufacturers i.e. General Dynamics Ordnance and Tactical Systems – Canada Inc., Olin Corporation, and Remington Arms Company. General Dynamics Ordnance and Tactical Systems – Canada Inc specializes in military applications. Two of the major importers are distributors (i.e. Korth and North Sylva/Parklands Manor) and one of the major importers is a major retailer of ammunition i.e. Cabelas (importing under the name 'SIR Mail Order'). The cartridges imported by Hilti are power device cartridges (PDCs) which are rimfire blank cartridges used to fire nails into concrete (Hilti (Canada) Corporation, pers. comm. 12 Dec 2016) - these cartridges are not relevant to this study.

The following table shows available market concentration data for cartridges, nes and parts thereof imports (see Table 13)

Table 13. Market Concentration for Cartridges, nes and parts thereof HS 930630 (2014)

Number of Importers	**Value of Imports ($CDN)**	**Cumulative % of Imports**
3	72,815,127	54.06%
6	95,065,020	70.58%
9	105,878,306	78.61%
All	**134,682,785**	**100%**

Source: Canadian Importers Database (CID) latest data available is 2014. Industry Canada: https://www.ic.gc.ca/app/scr/ic/sbms/cid/searchProduct.html?lang=eng

Nine companies are responsible for >78% of cartridge, nes and parts thereof imports into Canada. The total number of importers is not publicly available from CID.

2.2.3.1 Import Volumes for Cartridges, nes and parts thereof (HS 930630)

Note that this HS code includes 'cartridges other than shotgun with projectile – for rifle/pistol' (i.e. HS 9306304110[22] and HS 9306304120).

Available data on the quantity of imports were obtained from CIMT indicating that the majority of cartridges imported under this HS code are imported from the US. CIMT does not provide the quantity of cartridges publicly for this HS Code so the value of imports can be used as a proxy to assess relative import quantities.

Table 14 provides details on the value of imports for the period 2012-2015.

Table 14: Cartridges, nes and parts thereof, Imports by Country of Origin 2012-2015 (HS 930630)

Rank	Country	2015		2014		2013		2012	
		Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)	Quantity (N/A)	Value (CAN$)
		Trade amount							
Total	World	0	87,975,438	0	144,197,354	0	133,808,744	0	112,233,884
1	United States	0	76,256,138	0	118,191,544	0	72,305,115	0	71,609,238
2	Germany	0	3,099,425	0	4,600,066	0	7,916,941	0	7,174,029
3	Korea, South	0	1,530,694	0	2,587,840	0	496,006	0	575,138
4	United Kingdom	0	1,220,403	0	203,121	0	182,813	0	617,173
5	China	0	1,087,075	0	908,346	0	3,073,541	0	2,973,774
6	Czech Republic	0	959,019	0	2,481,072	0	2,748,199	0	1,991,374
7	Finland	0	723,822	0	2,611,227	0	1,883,920	0	515,008
8	Russian Federation	0	620,006	0	2,897,530	0	2,372,926	0	2,016,542
9	Austria	0	464,747	0	846,782	0	896	0	640
10	Israel	0	455,605	0	119,050	0	0	0	0

Source: CIMT (Statistics Canada): http://www5.statcan.gc.ca/cimt-cicm/

There was an increase in the value of these cartridge imports between 2012 and 2014 but a drop in import value between 2014 and 2015. The majority of imports in 2015 (>85%) came from the US.

In 2015, 69,595,950 cartridges for rifle/pistol (other than .22 cal, HS 9306.30.4120) with a total value of $52.2 million (USD) were exported from the US to Canada, (National Shooting Sports Foundation, US, pers. comm. 07 Dec 2016). The bulk of the imports captured by the CIMT data under HS 930630 are due to cartridges for rifle/pistol imported from the US. The average price per cartridge imported into Canada from the US under HS9306.30.4120 in 2015 was C$0.99[23].

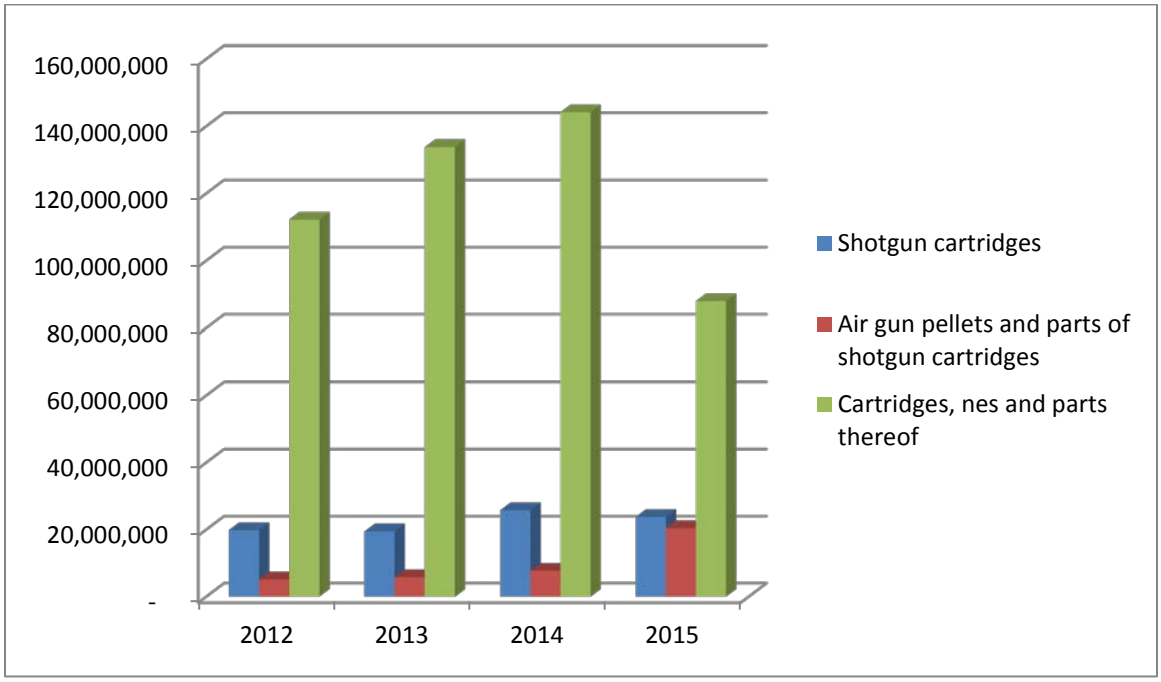
2.2.4 Summary of Data on Major Ammunition Importers and Imports from CID and CIMT

Figure 2 summarizes recent trends in ammunition imports 2012-2015 based on CIMT data.

[22] There were no exports of cartridges reported under HS 9306.30.4110 from the US to Canada in 2015.

[23] Exports from the US under HS9306.30.4120 were 69,565,950 cartridges with a total value of US$52,174,464 in 2015 indicating an average value per cartridge of US$0.75. Based on an exchange rate of US$1 =C$1.13136 (on Dec 12th, 2016) this equates to C$0.99 per cartridge.

Figure 2. Total Value of Ammunition Imports (C$) from Statistics Canada for 2012-1015



Source: Statistics Canada (CIMT) Total Value of Imports (C$) for HS930621 (shotgun cartridges), HS 930629 (air gun pellets and parts of shotgun cartridges) and HS 930630 (Cartridges nes and parts thereof)

The terms of reference for this study request details on company revenues, number of employees, distribution by province, and types and quantities of ammunition imported. A consolidated summary of major importers is provided in Appendix 1. Table 15 summarizes provincial distribution for the major importers.

The provincial distribution of major importers identified via CID is summarized in Table 15:

Table 15. Geographical Distribution of Major Importers

Importer location by Province (based on CID importer of record address)	Number of Importers
ON	3
QC	3
MB	2
AB	1
BC	1
USA-based importers	3

Source: Industry Canada, Canadian Importers Database (CID) latest data available (2014)

Some importers are also wholesale distributors (e.g. Korth, North Sylva/Parklands Manor) and distribute directly to retail stores[24]. Most US-manufacturers use representatives/agents in Canada that distribute their products. The following table provides a list of the major ammunition importers ranked by the total value of the ammunition imports in 2015.

[24] Pers. comm. from Distributor 2016

Table 16. Top Ten Importers of Ammunition Ranked by Total Value of Imports

Rank	Importer Name*	Import Value (C$)	Importer Type
1		$10,000,000 – $100,000,000	Distributor
2		$10,000,000 – $100,000,000	Government: End User
3		$10,000,000 – $100,000,000	Manufacturer
4		$10,000,000 – $100,000,000	Manufacturer
5		$1,000,000 – $10,000,000 $1,000,000 – $10,000,000	Retailer
6		$1,000,000 – $10,000,000	Distributor
7		$1,000,000 – $10,000,000	Distributor
8		$1,000,000 – $10,000,000	Retailer
9		$1,000,000 – $10,000,000	Retailer
10		$1,000,000 – $10,000,000	Retailer

Source: *Companies can import under several names – where this is the case, the multiple names used by a single company are included here. **These companies are combined as Bass Pro Shops acquired Cabela's in 2016 hence these are now owned by one company. Based on CBSA import data received January 2017 sanitized to protect CBI hence only ranges for import value provided. Quantity of imports (e.g. number of cartridges) not available from CBSA. Covers data reported to CBSA by importers under the following ammunition specific HS codes: 9306210000; 9306290000; 9306309012; 9306309019; 9306309024; 9306309029; 9306909030. The import value range in the table is based on the sum of import values under these ammunition import codes. Only cartridge imports relevant to this study included e.g. blank cartridges used to fire nails into concrete and similar blank cartridges (not expected to contain projectiles relevant to this study) removed from the data set received from CBSA

Most of the major importers are distributors and retailers. Note that importers that are distributors can supply both major retailers and smaller retailers with ammunition. Retailers that are importers (e.g. Cabela's, Bass Pro Shops, Wholesale Sports, Canadian Tire. Lawry Shooting Sports) may import some of the ammunition products they sell directly, but also obtain additional ammunition products via distributors. For example, as well as importing ammunition directly Canadian Tire obtains ammunition from a number of distributors and has 9 different vendors from which it obtains ammunition[25]. Hence the total value of imports shown in Table 16 above for retailers is not expected to cover all ammunition supplied to, or ultimately sold by, retailers as their supplies are obtained from multiple sources. Two ammunition manufacturers are in the top ten importers; (1) Olin (Winchester) imports some of its products into Canada directly and uses a variety of distributors to distribute its ammunition products to retailers in Canada (e.g. the distributors used by Olin (Winchester) include Graywood Sporting Group Inc. and its distribution partners which include Bowmac Gunpar, North Sylva/Parklands Manor, REDL/Maurice Sporting Goods etc.), (2) General Dynamics and Ordnance and Tactical Systems is a manufacturer that specializes in military applications hence it is likely that these imports fall outside the scope of

[25] Major retailer, pers. comm. 2016

this study (this company was contacted but did not respond to requests for information to confirm). The Government of Canada is also a major importer of ammunition – it is expected that these imports would be for law enforcement and military applications.

2.3 Major Retailers Profile

The retailers expected to control the majority of the market for ammunition in Canada are the large big box stores/ outfitters i.e. Canadian Tire, Cabelas/Bass Pro Shops, Walmart and Wholesale Sports. The terms of reference for this study requested details on revenues, number of employees, distribution by province, and company size for major retailers of ammunition. These data are therefore summarized in the following table. None of these major retailers provided data for this study. It is therefore not possible to provide details on aspects such market share for ammunition, the percentage of sales due to ammunition, or to rank the retailers based on total sales of ammunition. The major retailers of ammunition in Canada are profiled based on publicly available data in the following Table 17. They are listed in alphabetical order.

Table 17: Major Retailers

Company Name	Stores	Number Employees	Gross Annual Revenue	Street	City	Province	Postal code
Canadian Tire Corporation Ltd	493 stores across Canada, HQ in Toronto	27,772	$12,462 million	2180 Yonge Street, Suite	Toronto	ON	M4P 2V8
Cabela's Canada & Bass Pro Shops (note US and Canadian operations of Cabelas bought by Bass Pro for $2.25 billion in Oct 2016)	65 stores in US and Canada combined. HQ in Winnipeg with 70,000-square-foot location at 25 De Baets St, Winnipeg, plus 10 stores in Canada: http://www.cabelas.ca/find-a-store	19,700	~$500 million in Canada (Cabelas & Bass Pro); $3 billion in sales for US and Canada combined	25 De Baets Street	Winnipeg	MB	R2J 4G5
Wal-Mart Canada Corp	~395 stores across Canada	89, 358	$6,500 million	1940 Argentia Rd	Mississauga	ON	L5N 1P9
Wholesale Sports Outdoor Outfitters "Canada's Outdoor Outfitter Wholesale Sports" (subsidiary of United Farmers of Alberta (UFA) Co-operative Ltd; Acquired by UFA in 2008)	13 stores, e-commerce business and 470,000 square feet of retail space across British Columbia, Alberta, Saskatchewan and Manitoba,. Annual Report 2015 states "Wholesale Sports is the largest multi-channel retailer in Western Canada dedicated to the outdoors" Note recently closed Regina store in face of competition from new larger Cabelas store in 2016.	501-1000	$113 million (Wholesale Sports Outdoor Outfitters); $1,591 million (UFA)	25 Heritage Meadows Way SE	Calgary	AB	T2H 0A7

All the major retailers sell lead ammunition and non-lead alternatives. There are also many smaller independent stores across Canada that sell sporting goods/hunting and shooting supplies including ammunition.

The Retail Council of Canada (RCC) represents these major retailers (including Canadian Tire, Cabelas and Walmart[26]) and discussed the lead surveys with their members. The feedback from members was that they could not provide the information requested so the Retail Council of Canada was not prepared to facilitate distribution of the surveys to their members (Retail Council of Canada, pers. comm. 09 Dec 2016). All the major retailers were contacted directly and asked to provide data on their annual ammunition sales. None responded with data. In order to obtain data from retailers of ammunition it is recommended that ECCC utilize Section 71 of CEPA requiring mandatory reporting of data.

Retailers that specialize in selling ammunition and fishing supplies fall under NAICS 451119 'All Other Sporting Goods Stores' hence data for NAICS 451119 also provides a useful overview of this industry sector, particularly in regards to the numerous smaller retailers.

Industry Canada provides the following definition for NAICS 451119 'All Other Sporting Goods Stores':

"This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in retailing new sporting goods. These establishments may retail used sporting goods, and also provide repair services. Example Activities: Backpacking, hiking and mountaineering equipment, retail Bait and tackle shops, retail Bowling equipment and supplies, retail Camping equipment (except tent trailers), retail Firearms and ammunition, retail Gymnasium equipment, retail Hunting equipment, retail Playground equipment, retail Pool and billiard table stores, retail Skin diving and scuba equipment, retail".[27]

Industry Canada provides the following information on establishments by company size for NAICS 45119:

Table 18. Number of Employer Establishments 'All Other Sporting Goods Stores' (NAICS 451119) Dec 2014

Number of employer establishments by employment size category and province/territory: December 2014 **All Other Sporting Goods Stores (NAICS 451119)**				
Province or Territory	**Employment Size Category (Number of employees)**			
	Micro 1-4	**Small 5-99**	**Medium 100-499**	**Large 500+**
Alberta	78	199	8	0
British Columbia	140	276	11	0
Manitoba	30	41	1	0
New Brunswick	27	21	0	0
Newfoundland and Labrador	10	21	0	0
Northwest Territories	0	1	0	0
Nova Scotia	29	51	0	0
Nunavut	1	0	0	0

[26] It was not possible to determine whether Wholesale Sports is a member of RCC.
[27] Industry Canada, Canadian Industry Statistics: https://www.ic.gc.ca/app/scr/sbms/sbb/cis/definition.html?code=451119&lang=eng

Ontario	227	423	15	0
Prince Edward Island	10	5	0	0
Quebec	152	362	8	0
Saskatchewan	24	49	2	0
Yukon Territory	1	4	0	0
CANADA	729	1,453	45	0
Percent Distribution	32.7%	65.2%	2.0%	0.0%

Source: Statistics Canada, Canadian Business Patterns Database, December 2014. From: Industry Canada: https://strategis.ic.gc.ca/app/scr/sbms/sbb/cis/establishments.html?code=451119&lang=eng

In 2014, the breakdown of employer establishments in the All Other Sporting Goods Stores national industry was as follows: 32.7% of them were considered micro, employing less than five employees. Small establishments accounted for 65.2% and medium-sized establishments accounted for an additional 2.0% of the total number of establishments.

Industry Canada data indicates that 68.8% of the businesses in this sector were profitable in 2014 with average annual revenues of $863,200 and average net profits of $65,800. In 2014, 31.2% of the businesses were non-profitable with annual average revenues of $614,200 and net losses of -$48,100.[28]

2.4 Non-traditional Distribution

Non-traditional distribution of ammunition includes online retailers, sales at gun shows and similar sporting events, shooting ranges selling ammunition directly to members, and individual distributors.

Individuals and companies that sell ammunition, including non-traditional distributors, require a licence[29] as all businesses and organizations that produce, sell, possess, handle, display or store firearms or ammunition are required to have a licence. These must be obtained from the Chief Firearms Officer (CFO) of each Province and Territory.[30] Note that:

There are currently three types of firearms licences for individuals in Canada: the Possession and Acquisition Licence (PAL), the Possession Only Licence (POL) and the Minor's Licence. Only the PAL and Minor's Licence are available for new applicants.

- Possession and Acquisition Licence (PAL): allows the licence holder to possess and acquire firearms and ammunition.
- Possession Only Licence (POL): allows the licence holder to possess, but not acquire, firearms, and to both possess and acquire ammunition.
- Minor's Licence: the only licence available to individuals under 18 years of age. It allows the licence holder to use non-restricted firearms for specific activities such as hunting or target practice.

[28] Industry Canada Financial Performance data for NAICS 451119 (Dec 2014): https://strategis.ic.gc.ca/app/scr/sbms/sbb/cis/financialPerformance.html?code=451119&lang=eng
[29] http://www.rcmp-grc.gc.ca/cfp-pcaf/fs-fd/fab-eaf-eng.htm
[30] Contacts for CFOs across Canada: http://www.rcmp-grc.gc.ca/cfp-pcaf/cfo-caf/index-eng.htm

Table 19: Valid Firearms Licences as of December 2014

Province/Territory	Possession Licence	Possession and Acquisition Licence	Minor Licence	Total
Alberta	47,840	211,999	1,796	261,635
British Columbia	60,034	191,504	639	252,177
Manitoba	20,326	63,915	455	84,696
New Brunswick	31,332	37,361	199	68,892
Newfoundland and Labrador	22,078	50,943	295	73,316
Northwest Territories	413	4,798	29	5,240
Nova Scotia	32,044	40,065	1,235	73,344
Nunavut	31	3,069	2	3,102
Ontario	157,589	398,339	4,690	560,618
Prince Edward Island	2,414	3,729	19	6,162
Quebec	133,225	362,262	50	495,537
Saskatchewan	23,416	74,144	225	97,785
Yukon	854	5,765	58	6,677
Total	**531,596**	**1,447,893**	**9,692**	**1,989,181**

Source: RCMP http://www.rcmp-grc.gc.ca/cfp-pcaf/facts-faits/index-eng.htm (accessed Oct 2016). See Section 3.3.5.1 for trends in firearms licences in recent years.

A number of online ammunition retailers were contacted for information but none was prepared to provide data. Purchasers of ammunition are required to show the appropriate firearms licence (PAL) in person with ID hence online sales should not be possible[31]. However online retailers appear to be circumventing this requirement by accepting faxed or scanned copies of PALs.

[31] Ammunition manufacturer (pers. comm. Nov 2016)

Some shooting ranges have responded to requests for information indicating that some ranges do sell ammunition on site. Too few ranges have responded to allow the total amount sold via this route to be quantified.

Some ammunition users buy their ammunition from individuals who transport ammunition supplies to shooting clubs and ranges and sell them on site. Typically these individuals buy a shipment of ammunition, store it in their garage or warehouse, and then use a flat-bed truck to take these supplies to shooting clubs/facilities and sell them directly to end-users e.g. in the car park at the range.[32] These individual distributors are expected to be numerous and very hard to track. It would be impossible to provide details on revenue, types and quantity of ammunition sold per year etc. for these distributors. It should be noted that shooting ranges that provided information indicated that they do not generally encourage or support this type of ammunition distribution. The quantity of ammunition distributed in this way is expected to be very low when compared to distribution and sales via traditional channels.

There is no publicly available data on sales of ammunition in Canada at gun shows and other sporting events. Manufacturers/distributors and retailers may be able to provide information on their percentage sales through non-traditional routes however major stakeholders at all levels of the supply chain were not prepared to provide data for this study .

The electronic hunter survey[33] requested information on where they bought their ammunition, of the 512 that responded to this question >80% indicated that they purchased their ammunition from traditional storefronts (large retailers and local outfitters/sporting goods stores). Approximately 50% of respondents also indicated that they reloaded at least some of their own ammunition. Approximately 9% indicated that they bought ammunition online, <5% bought ammunition from an individual that brings ammunition supplies to their shooting range/club and <2% use the services of a commercial reloading company. Respondents to the survey acquired ammunition from multiple sources so the percentages will not add up to 100%.

Distribution of ammunition in Canada is therefore primarily via traditional supply chain routes with most ammunition purchased at traditional storefronts.

2.5 Shooting Ranges

The major facilities that allow the use of ammunition are various types of shooting ranges. Various sport shooting activities can take place at shooting ranges (target shooting (indoor and outdoor) trap and skeet, sporting clays etc.) and vary depending on the individual range and the available facilities. Shooting ranges vary widely in size and the facilities available on site. Discussions with individual shooting range officers and members indicate that many ranges in Canada are small and volunteer run. For example, of ~125 shooting range locations in Alberta only 4 are identified as being commercial operations, and 42 have less than 100 members [34] (see section 2.5.1 for further details).

Some shooting ranges provide details of their facilities and types of shooting activities that take place on site on their websites, additional data from the RCMP were also obtained for some regions – these details are summarized and provided to ECCC as a separate MSExcel spreadsheet on shooting ranges[35]. For some ranges, there is very little detail publicly available. Shooting ranges that provided contact details and emails on their websites were contacted with some brief initial questions to determine their level of knowledge regarding the ammunition used on site, and to see how many ranges would be willing to engage and provide information. When responses were received indicating some knowledge of ammunition uses on site, follow-up emails and/or phone calls were then used to gather more detailed information where required. In this regard, a small number of ranges were helpful and willing to provide information. However, even in these cases, ranges could only provide limited information - since shooting ranges are not required to record ammunition uses on site. They

[32] Prof. V. Thomas pers comm. Oct 11, 2016

[33] Hunter Survey (2017) questionnaire is provided in Appendix 2

[34] Note that the number of members is not available for all ranges – 42 of the shooting ranges for which member number is available have <100 members.

[35] Too few shooting ranges provided information for this study so the listing of Canadian ranges cannot be reliably sorted based on size or other relevant parameters such as type and quantity of ammunition used.

simply do not record, and hence do not have access to, the level of detail regarding ammunition uses requested. Responses from many shooting ranges indicated a great deal of suspicion and paranoia regarding a government study on ammunition and some were defiant and aggressive in their non-engagement responses.

The uses of ammunition, in terms of the average number of rounds discharged per week or over the course of a year, and the type of ammunition used, will vary between shooting disciplines and from shooter to shooter. The level of activity between shooters ranges widely from avid, competitive shooters using the range on a frequent basis to casual shooters who may use the range only a few times a year. Some hunters may only use the range during a short period of time just prior to hunting season (e.g. Aug/Sept) to practice.

Some information on this aspect is available from shooting websites and forums, from consultations with shooting ranges, and from the peer-reviewed scientific literature.

Some examples of available usage data include the following:

- Target practice with handguns can use several hundred rounds per hour (e.g. using cheaper .22 ammunition) or be as low as 20-30 rounds per session (e.g. using more expensive centrefire ammunition). Some shooters may do target practice weekly using an average of 300 shots per week.[36]
- A shooting range in Ontario indicated that the average shooter at their range fires 100 rounds per visit once per week (averaging ~5,200 rounds per year), although a particularly avid shooter may fire up to 43,000 rounds a year.[37]
- Ranges, or parts of ranges, can be shut down to members when training of enforcement groups such RCMP/Emergency Response Team (ERT) training is taking place at the range; 4,000-5,000 rounds of pistol (9mm) ammunition can be fired in a single training session lasting 4-5 hours - training sessions can be held every 2 weeks.[38]
- A shooting range in Ontario indicated that up to 4 million rounds were discharged annually at their range, including law enforcement rentals, and that at least 96-97% of this was lead.[39]
- A shooting range in BC with >300 members estimated an annual average of 5 visits per day and a total discharge of 85,000 rounds per year (including shotgun, pistol and rifle rounds), with 45 cartridges being discharged on average per person per visit, and 100% of this was lead ammunition.[40]
- Similarly, a range in NB with 120 members estimated that an average of 50 cartridges were discharged per shooter per visit (trap & skeet, sporting clays) with an annual total of 250,000 cartridges per year and 100% of this was lead.[41]
- A study by Thomas and Guitart (2010) that indicated that on average a shooter in the EU used 6.122 kg per year of lead projectiles.[42]

Relatively few ranges in Canada responded to requests for information limiting the available data for estimating and describing total uses of ammunition at Canadian ranges.

The typical shooting sports that occur at ranges in Canada are described in the following sections.

[36] For example, see information on shooting forums such as https://thefiringline.com/forums/showthread.php?t=477166 / http://www.handgunforum.net/range-report/22274-how-many-rounds-do-you-shoot-when-you-go-range.html

[37] Pers. comm. 2017

[38] Pers. comm. 2017

[39] Pers. comm. 2016.

[40] Pers. comm. 2016

[41] Pers. comm. 2016

[42] Thomas and Guitart. 2010. Limitations of European Union policy and law for regulating use of lead shot and sinkers: comparisons with North American regulation. Environment Policy and Governance 20: 57-72.

2.5.1 Trap and Skeet / Sporting Clays

The amount and type of ammunition used for some specific sport shooting activities (e.g. trap/skeet and sporting clay shooting) can be fairly standard and predictable. Trapshooting requires a device, called a trap, which throws clay targets into the air. Participants shoot at the clay targets thrown from a trap house located in front of the shooter. The trap rotates in a random sequence, presenting the shooter with a variety of going away shots, angling to the right, left and flying straightaway. Trap is usually shot in squads of five shooters. A round of trap consists of 25 targets per shooter. A trap field has five positions, or stations, numbered consecutively from left to right. Five clay targets, sometimes referred to as "birds," are thrown for each shooter at each position, with one shot being fired at each bird. After firing five rounds in rotation, each squad member moves one station to his right, with the shooter on station five moving over to station one.

Skeet shooting is similar to trap shooting and it uses the same clay targets. Two trap houses are required in skeet-a "high house" at the left of the field and a "low house" at the right. Both traps throw targets at fixed angles. A round of skeet consists of 25 targets. Some stations offer single targets, others doubles. There are 16 single targets, two from each station. A round also includes eight shots at four double-targets from stations 1, 2, 6 and 7. The first target missed is repeated; the repeat target is called "the optional." If no misses occur in the round of 24 shots, the optional is taken as a single target; usually shot from station eight.

Sporting clays is a clay target game designed to simulate a variety of field-shooting situations. On a sporting clays course, shooters are presented with a wide variety of targets that duplicate the flight path of game birds, such as flushing, crossing, incoming and other angling shots. Courses are laid out in natural surroundings and typically include five or more shooting stations. Like golf, shooters move from one station to the next to complete the course. At any station, targets may be thrown as singles, simultaneous pairs, following pairs (one target right after the other) or report pairs (the second target launched at the sound of the gun being fired at the first). To further challenge shooters, target size may vary from the standard trap/skeet clay bird to the smaller "midi" and "mini" targets, or a flat disc-shaped "battue" target. There are also "rabbit" targets, special clay disks that are thrown on edge to roll and skitter unpredictably across the ground. Sporting clays allows for either a pre-mounted or low gun approach, and a full round usually consists of 50 or 100 targets (depending on the number of stations), with several targets normally thrown at each station.

For skeet and trap shooting, it is normal for 25 cartridges to be used to shoot at 25 targets. In sporting clays shooting, some doubles targets are broken during launch, and so a 100 target round may require more than 100 cartridges to be shot.

2.5.2 Target Sports – Rifle/Handgun

Target shooting sports involve the use of various types of targets and firearms. The most popular target sports using handguns and rifles are described below.[43]

2.5.2.1 Handgun Sports

Some examples of handgun sports are provided below.

2.5.2.1.1 Action Shooting

Action shooting is a game measuring the speed at which a competitor can hit one or more targets, starting from a position in which the handgun is securely holstered. Targets may be stationary or moving. Action courses vary, often including both scored targets and falling targets within the same match. Within this is ‘cowboy action’ which is timed shooting against a wide variety of targets usually using a single action revolver.

[43] Details from the International Sports Shooting Federation and National Sport shooting Federation: http://www.issf-sports.org/ and http://www.nssf.org/shooting/sports/pistol.cfm

2.5.2.1.2 Silhouette Shooting

Silhouette shooting involves shooting silhouette targets off their stands; the metallic silhouette targets are placed at different distances.

2.5.2.1.3 Precision Shooting

Shooters are permitted to use only one hand while engaging targets at ranges varying from 10 metres to 50 metres.

2.5.2.1.4 Other

In addition, handgun ranges of various lengths (both indoor and outdoor) can be used for informal target practice. Informal target practice can also be referred to as 'plinking'.

2.5.2.2 Rifle Sports

Examples of rifle sports are provided below.

2.5.2.2.1 Bench Rest

Bench rest shooting is a form of precision marksmanship. Bench rest matches are fired from a shooting bench with the rifle supported by a front and rear rest. A course of fire consists of either five or 10 rounds, shot at a single target to produce a measurable group.

2.5.2.2.2 Silhouette

Silhouette shooting involves firing at metallic targets of different shapes from various distances up to 500 metres. Unlike most conventional target games that utilize paper targets and numerical scoring rings, almost every shot fired at a metallic silhouette produces an immediate and clearly visible result. For each five-round stage (one shot, left to right, at each target in a bank of five) a shooter is allowed a maximum of 2 1/2 minutes.

2.5.2.2.3 Position

Position shooting requires competitors to shoot from various positions during different match stages. A typical match will consist of several stages fired at different distances from each position. The target is a round bull's eye with numerical scoring rings radiating outward from center 10-ring or X-ring. Time limits vary with the stage and yardage. For example, high-power shooters firing at 600 yards are allotted 20 minutes for 20 shots, and the rapid-fire stage, fired at 200 yards, allows 60 seconds for 10 shots. Events can be shot from all three shooting positions; Standing, Prone and Kneeling.

2.5.2.2.4 Other

In addition, rifle ranges of various lengths (both indoor and outdoor) can be used for informal target practice or plinking. Air rifles can also be used for target practice at ranges and is often the way junior shooters are introduced into the shooting sports[44] Muzzle loading and Cowboy action shooting are concerned with shooting

[44] E.g. Barrie Gun Club: http://www.barriegunclub.org/junior-air-rifle/

replica (or antique) guns. Ranges can be used by hunters to sight-in their rifles and practice shooting before going hunting[45].

2.5.3 Outdoor Shooting Ranges Features

Typical features of an outdoor shooting range include firing points (where the firearm is discharged) and impact area (where projectiles are deposited). Impact areas often consist of soil and may be relatively flat (this is typical for shotgun ranges, including trap and skeet fields) or built up (backstops and berms present at rifle and pistol ranges). However, impact areas can also include water bodies, wetlands, forested areas or steep hillsides). On striking the berm or target, projectiles may penetrate the berm/target, ricochet, fragment or behave in other ways. Most of the projectile mass deposited in the impact area is in the form of intact projectiles or large fragments, although smaller fragments are also present. These fragments of varying size are subject to various physical and geochemical processes that control lead mobility in the environment.[46]

Shooting sports that use shotguns (e.g. trap and skeet, sporting clays) discharge lead projectiles over a diffuse area and a single cartridge may contain up to 36g[47] of lead, but a 32g load is the most common. In addition, large numbers of cartridges are used hence creating high lead shot densities in the impact area. The nature of trap and skeet shooting causes spent shot to land in a wide but predictable impact area. Sporting clays shooting typically takes place over 40-100 ha of land, and the continually changing layout of the course means that loadings of shot occur over a much wider area than for trap and skeet. Rifle and pistol shooting sports generally fire projectiles into backstops. Hence, these sports have lead accumulations in a more restricted area. Where projectiles are fired into earthen backstops lead may be readily removed from the backstops and recycled (Darling and Thomas, 2003).[48]

Typically for skeet/trap shooting a full box of 25 rounds is typically used (typically using 32g lead per shot with 12 gauge ammunition). One round of trap or skeet shooting (25 shots) will add therefore add 800 g of lead per shooter to the impact area. A session of sporting clay shooting uses 50 or 100 rounds and typically 12 gauge ammunition is used (containing 32g of lead per shot). A typical round of sporting clays (100 shots) will release 3.2 kg of lead per shooter to the impact area (Darling and Thomas, 2003).

Darling and Thomas (2003) noted that rifle/pistol target shooting sports that fire solid bullets into earthen backstops, while still presenting a potential environmental lead hazard, were less of a concern than shotgun sports (trap/skeet/sporting clays) due to the greater amount of lead per cartridge and the more diffuse fallout from discharged shot.

2.5.4 International Context

Recent studies have estimated that >100,000 shooting ranges exist all over the world, that the ammunition used at ranges is mainly composed of lead (90-99 wt%), and that up to 72,600 tons of lead from ammunition are scattered on soils each year via shooting sports (Rodriguez-Seijo *et al.*, 2017[49] and references therein). In the US, it has been estimated that ~20 million people participate in shooting sports.[50]

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[45] E.g. Sighting your Rifle: Texas Parks and Wildlife: https://tpwd.texas.gov/education/hunter-education/online-course/shooting-skills/sighting-in

[46] Morton, E Tetra Tech EM Inc. Chicago, IL, USA. Lead Mobility in Soil: A refresher. Policy Track: Environmental Issues. Fourth National Shooting Range Symposium, 89-94

[47] Shotgun cartridges typically used range from 7/8 oz (21g) to 1 ¼ oz (36g), with 1 1/8 oz (32g) being a typical average.

[48] Darling and Thomas (2003) The distribution of outdoor shooting ranges in Ontario and the potential for lead pollution of soil and water. Sci. Tot. Env. 313, 235-243

[49] Rodriguez-Seijo et al., 2016. Lead and PAHs contamination of an old shooting range: A case study with a holistic approach. Sci. Tot. Envi. (STOTEN) 575 (2017) 367-377

[50] NSSF: http://www.nssf.org/2013/shooting/sports/

2.5.5 Number and Type of Shooting Ranges in Canada

Publicly available data on shooting ranges in Canada was compiled and a brief summary of the number of ranges identified is provided below (see Table 20.)

Table 20. Total Number of Shooting Ranges in Canada based on publicly available data

Province/Territory	Total # Range Locations (note that within each of these locations there may be a number of different types of shooting range e.g. a single range location may contain an outdoor rifle range, a shotgun range, and a separate indoor handgun range)
Alberta	137
British Columbia	123
Manitoba	65
New Brunswick	76
Newfoundland and Labrador	18
Nova Scotia	81
Ontario	263*
Quebec	78
PEI	6
Saskatchewan	118
Yukon, NWT, Nunavut	6

Source: Based on publicly available data found by searching for shooting or gun ranges; lists of 'where to shoot' from shooting/gun clubs and associations, hunting and wildlife associations and federations, and details from individual range websites.*Total number from a newsletter from the Chief Firearms Officer of Ontario (2015)[51], publicly available information found for 211 of these.

Based on publicly available information 971 shooting ranges in Canada were identified. In addition, some of the range locations provided in the above table contain several different types of shooting range (e.g. a single range location/club may have multiple types of shooting range with its facilities e.g. one facility location may have outdoor shotgun ranges, outdoor rifle/pistol ranges, and an indoor range) depending on the club size and membership interests.

In addition, since most ranges need to be registered with the Chief Firearms Officer of each region, a list of registered shooting ranges from the RCMP was requested. The RCMP stated that data could not be provided unless an ATIP was submitted. An ATIP was therefore submitted. Data on registered shooting ranges for the following regions were obtained: British Columbia—Yukon (BC-YT), Alberta-Northwest Territories (AB-NT),

[51] RCMP CFO Ontario Newsletter to Shooting Clubs and Ranges Issue 6 (2015): http://www.creanhillgunclub.ca/Chief%20Firearms%20Office%20-%20Ontario%20Shooting%20Clubs%20and%20Ranges%20Newsletter%20-%202015%20Issue%206.pdf

Manitoba-Nunavut (MB-NU), Saskatchewan (SK), Newfoundland and Labrador (Nfld & Lab) although contact names and emails for range managers were redacted. Data was not be provided for ON, QC, NS, NB, or PEI. Table 21 below provides a summary of some of the data provided by the RCMP data. The complete data sets obtained from the RCMP were provided to ECCC. The information obtained provides club/range name, number of members (for some but not all ranges), type of shooting activities at each location, and range address. The data provided by RCMP on registered shooting ranges varied between regions with some regions providing more detailed data than others. For example, RCMP data on shooting ranges in Saskatchewan included a listing of the type and calibre of firearms that could be used at each location – the information from other regions was less detailed – identifying only whether handguns, rifles, and or shotguns were used at the ranges. Shooting range membership numbers were provided by RCMP for Alberta – Northwest Territories (AB-NT) but this information was not provided for any other jurisdiction. The data from the RCMP are summarized below.

Table 21. Summary of Data on Shooting Ranges received from RCMP

Region:	AB-NT	BC-YT	SK	MB-Nunavut	NFLD-Labrador
Total Number of Individual Ranges	347	256	250	112	14
Total Number Range Locations*	125	146	150	62	14
% Total ranges where handguns used	54%	50%	76%	77%	nd
% Total ranges where rifles used	49%	54%	69%	86%	nd
% Total ranges where shotguns used	30%	46%	41%	45%	nd
Total number of shooting/club range members reported	17,620**	nd	nd	nd	nd

Notes: *Each range location is typically operated by a single group/association. **Membership numbers only available for some ranges (115 of the 125 ranges in AB-NT); note also that for most ranges users need not be members to shoot at the range. Some individual ranges are dedicated shotgun ranges, or handgun ranges, some ranges are dedicated rifle ranges, and some are a combination rifle/handgun and/or shotgun so the percentages will not add up to 100% due to overlapping use patterns.

The RCMP data indicates that there are variations in the types of ranges between regions. For example, 86% of range locations in MB-Nunavut have rifle ranges whereas <50% of range locations in AB-NT have rifle ranges. BC-YT has the highest percentage of locations that contain shotgun ranges (46% of ranges in BC-YT contain a shotgun range) and AB-NT has the lowest reported incidence of shotgun ranges in the RCMP data set (30% of ranges in AB-NT contain a shotgun range).

Shooting range/club membership numbers were provided by the RCMP for most ranges in Alberta and indicated that the average number of members per club in Alberta was 155. No membership numbers were provided for other regions. Data collected from shooting range websites, and from consultations, also provided information on membership number for other regions – although the number of ranges for which this information was available was more limited than for AB. For example, the average number of members per range in BC was 264 (based on 8 ranges only; 32 members to 750 members in size), the average number of members per range in NB was 158 (based on 17 ranges; 25 members to 388 members in size). Insufficient information from other regions was available to calculate an average number of members per range. Based on all ranges for

which membership numbers were available (155 ranges in total), it was estimated that the average number of members per range was 192. This number could be refined if more data were made available by the RCMP/CFOs for the other regions and/or via further data input from ranges (e.g. a CEPA section 71 survey of ranges could be used).

The estimated average number of members per range was then used to provide an estimate of the number of shooting club/range members for all the AB ranges and the other provinces/territories where membership numbers were not available (see Table 22 below). This approach was used due to the lack of data on membership numbers for other provinces and territories. These estimates assume that the types, sizes and membership levels of shooting clubs in AB/BC/NB are reasonably representative of other regions in Canada. It is important to keep in mind that shooting club membership numbers provide an indication of shooting club size but do not cover all participants in the shooting sports, as membership is not always required to use shooting range facilities. Some ranges allow non-members to use the range facilities either as a guest of a member, or by paying a drop-in or per use fee. Table 22 also provides side-side comparison of the number of firearms licences issued per province/territory.

Table 22. Total Number of Shooting Ranges in Canada, Membership Numbers, and Firearms Licences

Province/Territory	Total # Range Locations*	Total Number Range Members	Total Number Firearms Licences (2014)	Firearms Licences per 100,000 population (2014)
Alberta	137	26,368	261,635	7,177
British Columbia	139	26,753	252,177	5,731
Manitoba	65	12,510	84,696	7,010
New Brunswick	76	14,628	68,892	9,171
Newfoundland and Labrador	18	3,464	73,316	14,249
Nova Scotia	81	15,590	73,344	7,957
Ontario	263	50,619	560,618	4,362
Quebec	232	44,743	495,537	6,270
PEI	6	1,155	6,162	4,395
Saskatchewan	150	28,870	97,789	9,463
Yukon	7	1,347	6,677	19,698
NWT	4	770	5,240	12,638
Nunavut	1	192	3,102	9,722
Total	**1025**	**227,010**	**1,989,181**	**5,942 (average)**

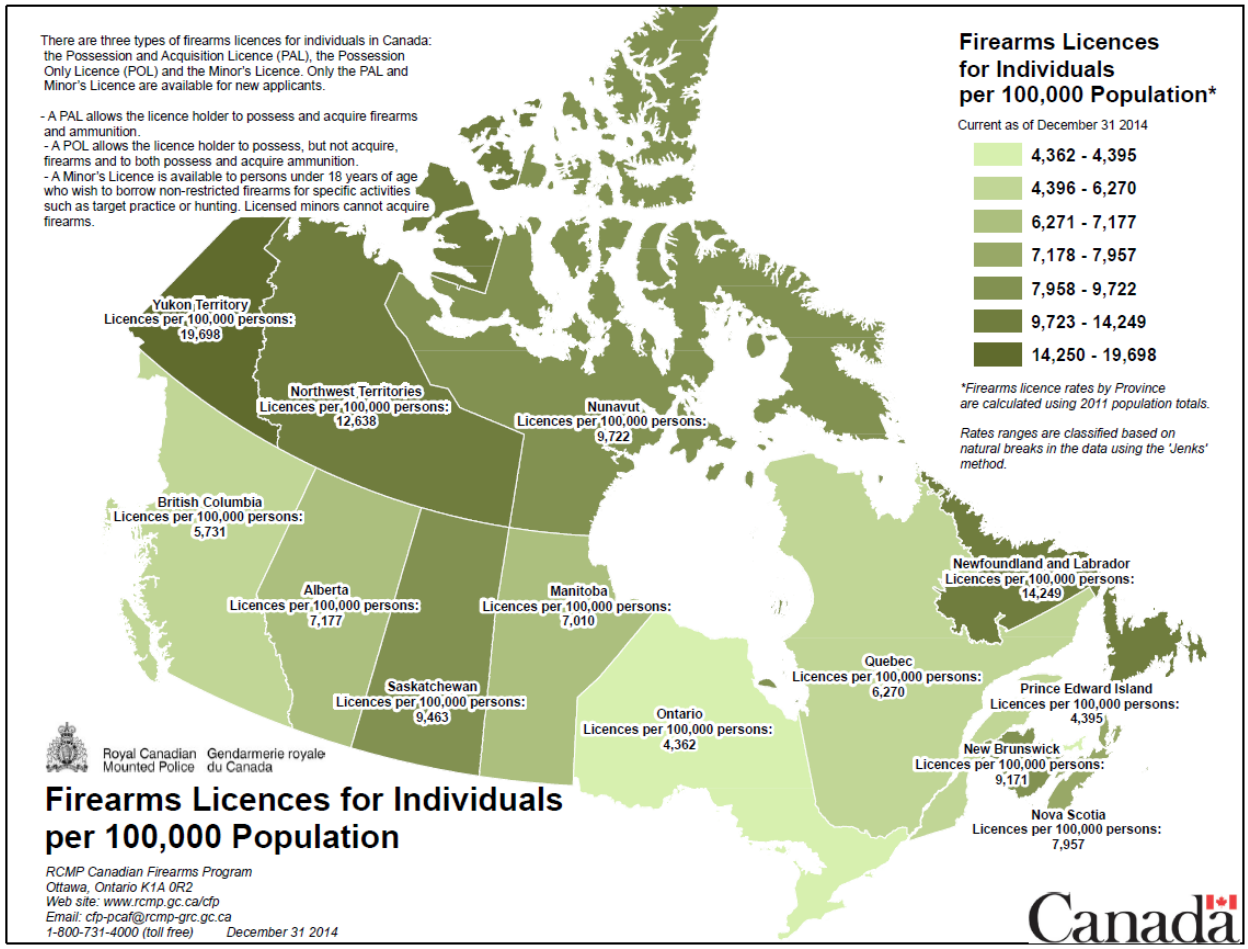
Source: Based on publicly available data or RCMP data where RCMP data were made available. **The number of ranges for Quebec was estimated assuming the ratio of shooting ranges to firearms licenses in Ontario was representative for QC also – this adjustment was done as relatively few ranges were identified in QC using web searches and no data for QC were provided by the CFO for QC. Note that club membership numbers are not expected to fully represent participation in shooting

sports at ranges in Canada as many clubs/ranges allow non-members to use their facilities. Each range location may include a number of individual shooting ranges.

It is therefore estimated that there are approximately 1025 shooting range locations in Canada with a total membership of >225,000. This indicates that on average across Canada ~10% of firearms licence holders are range members.

Figure 3 provides an illustration of the number of firearms licences issued across Canada per 100,000 population for 2014 (RCMP Data).

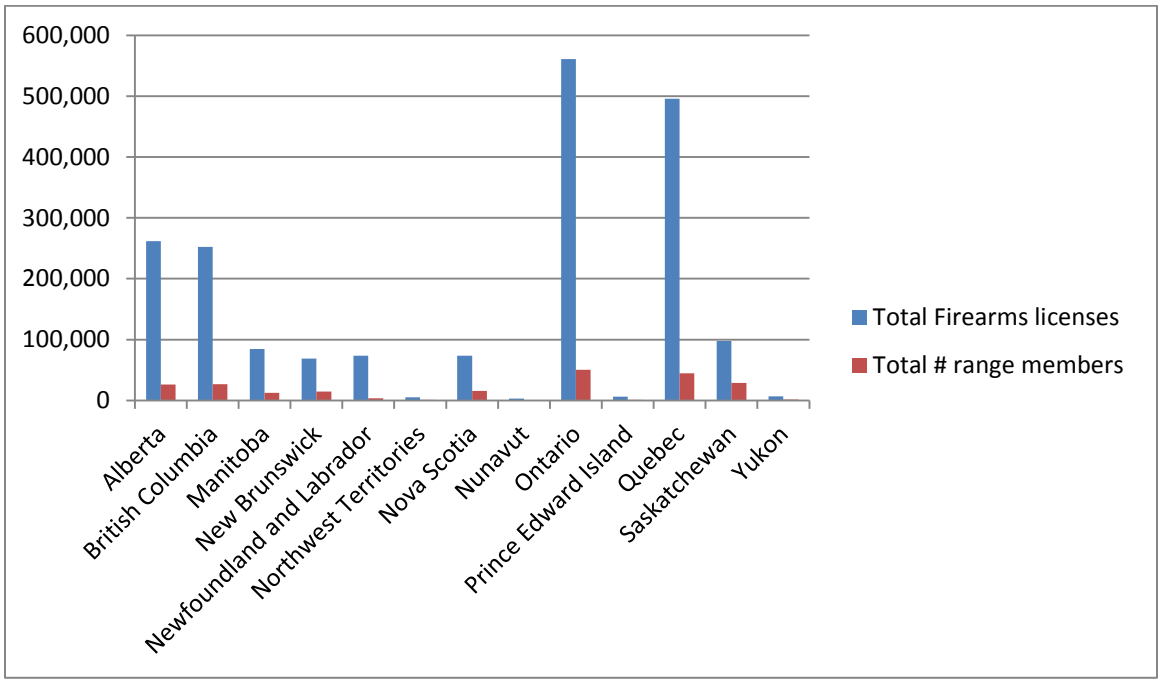
Figure 3. Firearms Licences Issued per 100,000 population (RCMP, 2014)



Source: RCMP: http://www.rcmp-grc.gc.ca/cfp-pcaf/facts-faits/index-eng.htm (accessed Oct 2016)

The following figure provides a comparison of the number of firearms licenses issued per province/territory and the total number of shooting range members (see Figure 4).

Figure 4. Firearms Licence Numbers and Shooting Range Membership Numbers



Not surprisingly, provinces where there are more firearms licence holders also have more shooting ranges and more shooting range members.

In addition, discussions with stakeholders (e.g. wildlife federations) indicate that there are some very informal/unlicensed shooting ranges (e.g. gravel pits used as shooting ranges, target shooting in pull outs along forest roads[52]) although these would be relatively small in number compared to licensed ranges and can be temporary in nature.

Although the RCMP for Ontario did not provide details on shooting ranges in Ontario, we were able to obtain information on ranges in Ontario from publicly available sources (e.g. range websites) via consultation with Ontario ranges (although relatively few ON ranges provided information), and from the peer-reviewed scientific literature (e.g. Darling and Thomas (2003)[53]).

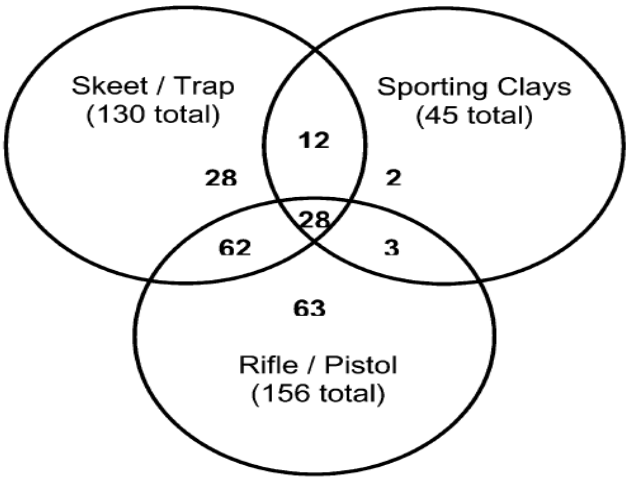
Darling and Thomas (2003) noted that the number and distribution of shooting ranges in Canada, and the potential lead contamination from discharged projectiles on ranges had never been calculated at a broad geographical scale. Darling and Thomas (2003) examined the distribution of shooting ranges in Ontario and found at least 211 active shooting ranges in the province at that time[54]. Of these, Darling and Thomas (2003) found that 135 ranges catered to shotgun sports. The categories of shooting sports found at Ontario shooting ranges are shown in Figure 5.

[52] E.g. see http://www.theprogress.com/news/326003971.html?print=true

[53] Darling and Thomas 2003. The distribution of outdoor shooting ranges in Ontario and the potential for lead pollution of soil and water. The Science of the Total Environment 313; 235-243

[54] Since that time the number of shooting ranges in Ontario has increased to 263 with 230 being club-run ranges and 33 private shooting ranges: http://www.creanhillgunclub.ca/Chief%20Firearms%20Office%20-%20Ontario%20Shooting%20Clubs%20and%20Ranges%20Newsletter%20-%202015%20Issue%206.pdf

Figure 5. Categories of shooting disciplines found in Ontario shooting ranges (from Darling and Thomas, 2003)



Note: Numbers in overlapping circles represent ranges that cater to more than one shooting sport.

The Darling and Thomas (2003) study was the first to compile data on the distribution of shooting ranges for Ontario and it revealed that far more ranges exist than previously estimated. For example, Scheuhammer *et al* (1995) estimated that there were approximately 120 trap shooting ranges in Canada whereas Darling and Thomas (2003) found that there were up to 130 trap/skeet ranges in Ontario alone (see Fig 2 above). It was found that 94% of Ontario ranges incorporated water bodies and it was noted that lead shot falling in wetlands can be ingested by waterfowl leading directly to lead poisoning and, additionally, be subject to dissolution in water. Darling and Thomas (2003) also found that soils at some shooting ranges exhibited a greater potential for mobilizing lead than at others (e.g. based on soil type and pH), especially in the central and northern regions of the province where brunisolic and podzolic soils predominate.

In summary, 1025 shooting range locations were identified in Canada. Each of these shooting range locations can contain different types of individual shooting range. Some larger shooting ranges have both indoor and outdoor shooting ranges, whilst others have only indoor or only outdoor ranges. We identified 155 indoor ranges in Canada based on publicly available information. RCMP data on Canadian shooting ranges indicates that 65% of shooting range locations in Canada contain rifle ranges, 64% contain handgun ranges, and 41% contain shotgun ranges. The number of members per range varies widely depending on the range size. Based on available data the average number of members per range in Canada was estimated to be 192 members per range. Waste management activities associated with shooting ranges are summarized in the following section (see section 2.6) and the quantity and type of ammunition used at shooting ranges is examined in more detail in section 3 of this report.

2.6 Waste Management

Available data for indoor ranges indicates that spent bullets from indoor ranges are generally collected for recycling. They are collected (e.g. by sweeping the indoor range, emptying bullet traps) and then recycled by individual members or sent to a metal reclamation company for recycling. It should be noted that most ranges that responded to the survey were very vague on ‘recycling’ and could not provide the names of the recycling companies that the collected bullets were sent to – some indicated that it was primarily members that ‘recycled’ the bullets. In addition, some outdoor ranges have regular ‘clean-up days’ – these volunteer activities are done by club members, particularly at small ranges, and include raking and/or sifting spent ammunition and bullet fragments from the upper layer of soil, removal of bullets from berms. These are considered low technology and low-cost management approaches for lead reclamation which can be used at some smaller, volunteer-run ranges. Reclamation at smaller shooting ranges can also be provided by very small local companies (e.g. owner

operators) using small 'lawnmower-sized' machines that scrape up the upper layer of soil and partially separate the spent ammunition from the soil, which can then be further separated using sifting. There is insufficient data currently available to quantify the amount of lead ammunition recovered by informal, volunteer efforts or very small operators at ranges.

There is evidence of professional reclamation and recycling activities at some outdoor ranges. In these cases general reclamation activities require that the top 10cm of soil is removed and a shaker is used to separate the spent ammunition from the soil. The recovered lead ammunition is sent to a metal recycling facility and the resulting profit is split between the reclamation company and the range[55]. There are a number of companies in the US that specialize in lead reclamation from firing ranges. One company, called MT2, has been used by several ranges in Canada in recent years. The amount of lead recycled and the profits returned to the participating ranges is summarized in Table 23.

Table 23: Reclamation Activities at Firing Ranges in Canada 2011-2016

Lead reclamation from ranges	**2011**	**2012**	**2013**
Quantity recovered and recycled	682 tonnes	114 tonnes	45.5 tonnes
Profit returned to range	>C$250,000	C$50,000	C$22,600

Source: 2011 by Maat Corporation (http://maatenv.com/) with 1.5 million lbs recovered in 2011 from Canadian shooting ranges, > 1million lbs recovered from a single range in Ontario; 2012-2013 data provided by MT2, pers. comm. Dec 2016 – based on reclamation and recycling of 2 ranges in Canada. No reclamation activities in Canada by Maat / MT2 in 2014-2016 as no ranges expressed interest.

The professional reclamation option may be more difficult for smaller ranges to utilize as the profits for the reclamation company may not be large enough for them to transport their equipment to the site and undertake the work[56]. In addition, the reclamation company MT2 has indicated that it also faces obstacles in undertaking more work of this type in Canada: "MT2 has been very interested in expanding into Canada. Our biggest obstacles have been receiving authorizations to allow our workers to work in Canada and a general lack of interest from Canadian range owners" (MT2, Dec 2016). MT2 is trying to promote the benefits of lead reclamation to shooting ranges across North America.[57]

Other remediation case-studies show that when shooting ranges are remediated the lead is not always recovered and recycled. For example, in 2010 the Strathcona shooting range in Alberta was remediated by the City of Edmonton with a cost of C$3.9 million - converting the 65-hectare site from a range used by 250 shooters day to a multi-sport recreational facility expected to be used by 9,200 people a day. The site had been used as a shooting range for 30 years. During the site remediation, 58,861 tonnes of contaminated soil were hauled to a Class 2 landfill; 3,151 tonnes of soil with hazardous lead concentrations were hauled to a Class 1 landfill, with no reports of lead recycling.[58] Remediation of the Glendale Ave Skeet Shooting Range (ON) in 2010 involved the removal of ~50,000 tonnes of contaminated soil from the site with a remediation cost of >C$3.8 million – the owner of the site was Transport Canada hence the costs were covered by the Federal Government[59]. Some shooting ranges that were established decades ago in historically unpopulated areas are

[55] Typically the split is 50:50 or 60:40 between the reclamation company and the range.
[56] Perspective from small range that looked into reclamation – responder requested anonymity (Dec 2016)
[57] MT2 recent efforts to promote lead reclamation to firing ranges: http://www.prnewswire.com/news-releases/firing-ranges-may-be-walking-away-from-a-fortune-in-lead-300086264.html and http://www.prnewswire.com/news-releases/mt2-announces-fall-tradeshow-appearances-at-upcoming-conferences-to-bring-awareness-to-lead-hazardous-waste-initiatives-for-the-firing-range-industry-300334594.html
[58] Strathcona Shooting Range Remediation: https://www.fcm.ca/Documents/case-studies/GMF/2006/GMF9391_strathcona_shooting_range_site_remediation_CS_EN.pdf
[59] Historical tab adds to clean-up tab at gun club: http://www.stcatharinesstandard.ca/2010/10/09/historical-dump-adds-to-cleanup-tab-at-gun-club

now being impacted by residential development and hence need to move – however, they cannot afford the costs of site remediation.[60]

The BC Wildlife Federation (BCWF) – which has 66 shooting ranges in BC as members - has examined the issue of lead management on shooting ranges and has developed some guidance for its members in this area. The BCWF developed a Best Management Practices (BMP) guide called 'Assessment of approaches for lead management for outdoor shooting ranges' in 2016 and plans to further refine this in 2017 (BCWF, Dec 2016). BCWF shared this BMP document with other wildlife federations in Canada but received no responses. The four-step approach proposed in the BMP is briefly outlined below.

Extract from the BCWF BMP (2016):

"To operate an outdoor range that is environmentally protective requires implementing an integrated lead management program, which incorporates a variety of appropriate best management practices (BMPs). These BMPs create a four step approach to lead management:

Step 1 - Control and contain lead bullets and bullet fragments.

Step 2 - Prevent migration of lead to the subsurface and surrounding surface water bodies.

Step 3 - Remove the lead from the range and recycle.

Step 4 - Documenting activities and keeping records.

An effective lead management plan will require implementing and evaluating BMPs from each of the 4 steps. It should be noted that steps 1-2 do not negate the need for removal of lead, but are practices that should be completed between lead reclamation events. It's also important to note that cost and complexity of practices vary greatly, and it is your ranges individual characteristics that will determine which should be implemented."

The table below provides a list of potential BMPs applicable to both shotgun ranges and rifle/pistol ranges (BCWF, 2016).

[60] Revelstoke Rod and Gun Club needs 'serious money' to move: http://www.revelstokereview.com/news/399237041.html (Consulted November 2016)

Table 24. Summary of Potential BMPs for Lead Management at Outdoor Ranges (BCWF, 2016)

	Shotgun Ranges	Rifle/Pistol Ranges
Potential Operational Approaches	• Shot recovery and recycling • Target recovery • Alternative shot materials • Lime and phosphate application	•Bullet recovery and recycling •Lime and phosphate application
Potential Engineering Approaches	• Range siting • Clay layer/mixing • Physical barriers to shot distribution • Shortfall zones designed to be outside of surface water bodies • Ranges designed to maximize overlap of shortfall zones, while maintain shooter safety • Elimination of depressions that may hold water • Storm water management/erosion control	• Range siting • Clay layers/mixing • Bullet containment • Baffles/tube ranges • Berm Construction and maintenance • Bullet traps • Runoff controls • Storm water management/erosion control

Source: BCWF (2016): Standards and Best Practices for Lead Management An assessment of approaches to lead management for outdoor shooting ranges

BCWF plans to develop this document further to ensure that the recommended approaches and BMPs for firing ranges are consistent with the requirements of the Provincial Waste Management Act (BCWF, pers. comm. Dec 2016).

US EPA also has best management practices for lead at outdoor shooting ranges which were published in 2005.[61]

2.7 Key associations

A list of key associations and interest groups was provided to ECCC as a separate MS Excel spreadsheet. Note that some key stakeholders cover issues related to hunting/shooting and angling – hence there is significant overlap between the stakeholders for ammunition and fishing sinkers and jigs.

[61] https://www3.epa.gov/region02/waste/leadshot/epa_bmp.pdf (Consulted November 2016)

3.0 Ammunition Products

The types of ammunition relevant to this study fall into a general grouping of 'small arms and light weapons ammunition'. Within this grouping this study focuses on the types of ammunition typically used for non-military purposes which are cartridge-based and under 12.7 mm calibre.

The cartridge is a self-contained unit comprising the cartridge case, the primer, the propellant (powder), and the projectile or 'bullet'. All weapons that fire cartridge-based ammunition have a barrel, which is integral to the process of delivering energy, momentum, and direction to the bullet. The operating principles of all weapons firing cartridge-based ammunition are the same. The cartridge partially seals the firing chamber of the weapon. On firing, a pin strikes the primer at the base of the cartridge and ignites it. This ignites the powder, which burns rapidly and generates expanding gases. The gases are forced down the length of the barrel, pushing the projectile(s) in front of them and eventually out of the barrel. At the same time, the cartridge case expands and completes the firing chamber seal. The momentum imparted by the process propels the projectile(s), but since there is no process within the projectile(s) to sustain movement, the projectile(s) begin to lose velocity shortly after leaving the barrel. Cartridge size differs from weapon to weapon in terms of calibre (i.e. diameter of the bullet) and in the overall length of the case. Longer cases contain more powder, which can impact more energy and hence higher velocities to the projectile(s).

Global production of ammunition is dominated by industrialized mass manufacturing. Previous studies on ammunition have noted difficulties in obtaining information on ammunition production stating that "it is difficult to determine how many ammunition production and assembly facilities exist around the world" due to lack of publicly available information and that "even if the total number of small arms producing facilities was known, this would not necessarily allow for reliable information on global annual production volumes because of the lack of transparency by many companies and countries about their potential and actual ammunition output[62]". Given the importance of US manufacturers in supplying the Canadian market, it is important to note that no comprehensive studies of the US firearms industry have been completed in recent decades. This is primarily due to the paucity of credible data and the difficulty accessing it – this is true for both data pertaining to the market as a whole and for individual companies.[63] Hence, there are widely recognized difficulties in obtaining data from the ammunition and firearms industry.

3.1 Lead in Ammunition

The amount of lead in each ammunition cartridge varies depending on whether the cartridge is designed for use with a shotgun (lead shot or slugs used in shotgun cartridges) or contained within the projectile used in a rifle/pistol cartridge. Within both the shotgun cartridge and rifle/pistol categories there are also a wide variety of different sizes of shotgun cartridges and bullets to choose from containing varying quantities of lead.

3.1.1 Composition

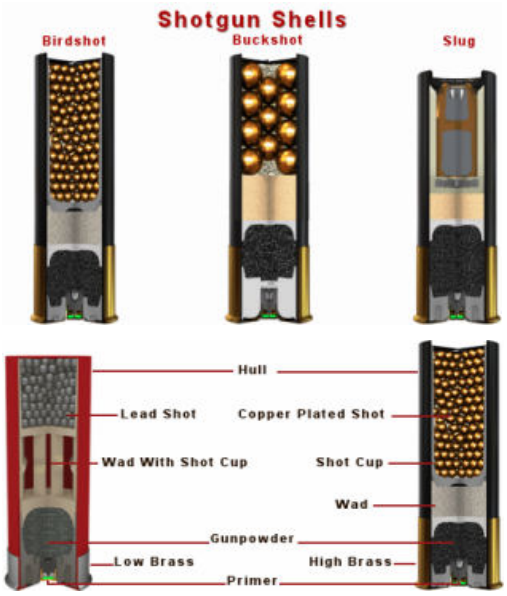
Shotgun cartridges contain projectiles (shot or slug) that are made of lead or an alternative material. The most commonly used alternative is steel/iron shot. The lead projectile(s) within the cartridge can be plated e.g. copper-plated lead shot. The total weight of projectile(s) in the cartridge is stated in the product description (usually in ounces).

[62] Targeting ammunition – A primer. Small Arms Survey, Graduate Institute of International Studies, Geneva 2006 http://www.smallarmssurvey.org/publications/by-type/book-series/targeting-ammunition.html

[63] The US Firearms Industry: Production and Supply. J. Brauer. Small Arms Survey, Graduate Institute of International Studies, Geneva 2013 http://www.smallarmssurvey.org/publications/by-region/americas.html

Figure 6. Shotgun Cartridges

(a)



(b) Sabot shotgun slugs

(c) Rifled shotgun slugs

Source: Gunnersden.com. Buckshot shotgun cartridges are used primarily for hunting larger game, such as deer, however it is also used in riot shotguns and combat shotguns for police use.

Modern shotgun cartridges typically consist of a plastic case (usually called the hull) with the base encased in a thin brass-plated steel covering. Some shotgun cartridges have metal extending up further along the sides of the cartridge – these are usually 'magnum' shotgun cartridges with more powerful (higher weight) loads (see Figure 6 [a]).

Shotgun cartridges have five and or six main parts:

- Hull: The hull holds the primer, powder, wad, and shot pellets.
- Primer: The primer's internal compound explodes when struck by the firing pin and ignites the powder.
- Gunpowder: The powder burns and creates expanding gases to move the wad, shot cup and shot down the barrel.
- Wad: The wad seals the gas behind the shot charge.
- Shot Cup: The shot cup protects the shot and the internal portion of the barrel.
- Shot: The shot (lead, steel, bismuth, iron, nickel plated and copper plated, pellets) that strike the intended target.

Slug shotgun cartridges use a heavy lead projectile, usually with pre-cut rifling, intended for use in a smoothbore shotgun barrel and often used for hunting large game (see Figure 6 (b)).

Saboted shotgun slugs can be used in shotguns produced with rifled barrels – the saboted slugs are designed to be fired from them with spin stabilization. Saboted slug shotgun cartridges usually use a lead-cored, full copper-jacketed projectile supported by a plastic sabot, which is designed to engage the rifling[64] in a rifled shotgun barrel and impart a spin onto the projectile (see Figure 6 (c)).

The following table provides publicly available information on the composition of shotgun cartridges from Federal Premium[65]. These composition data are designed to cover all of Federal Premium's shotgun cartridge products and are not specific to lead products. This composition breakdown includes the cartridge casing, primer and gunpowder i.e. the % (w/w) composition is not specific to the projectile. The available safety data sheets (SDS) from ammunition manufacturers combine multiple ammunition products into a single SDS likely to avoid disclosing composition details on individual ammunition types.

Table 25: Composition of shotgun ammunition (all gauges and shot types) (Brand: Federal Premium)

Substance	**CAS**	**% (w/w)**
Lead (as shot or slug)	7439-92-1	0-75
Antimony	7440-36-0	0-5
Copper (as shot, plating, brass or slug)	7440-50-8	0-75
Zinc	7440-66-6	0-5
Iron / Steel (as shot)	1309-37-1	0-75
Tungsten (as shot)	12604-57-8	0-60
Tin	7440-31-5	0-6
Polyethylene (as case)	9002-88-4	4-11
Nitrocellulose	9004-70-0	0.5-2
Nitroglycerin	55-63-0	2-5

[64] Rifling in this context refers to spiral grooves cut in the inner surface of the gun barrel to give the bullet a rotatory motion and thus a more precise trajectory

[65] SDS: http://www.federalpremium.com/ammunition/rifle/family/power-shok/power-shok-rifle/308a

Nickel	7440-02-0	0-6
Graphite	7782-42-5	<0.25

Source: SDS from Federal Premium dated Feb 08, 2016: http://www.federalpremium.com/ammunition/shotcartridge . Note that ammunition manufacturers combine multiple ammunition products onto single SDS likely to avoid disclosing details on the composition of individual ammunition products.

Olin Winchester provides the following composition information for lead shot and slugs used in shotgun cartridges – this is the composition for the lead projectiles only:

Table 26: Composition of lead shot / slugs (projectiles for shotgun cartridges) (Manufacturer: Olin Winchester)

Substance	**CAS**	**% (w/w)**
Lead	7439-92-1	99
Antimony	7440-36-0	1-5
Arsenic	7440-38-2	0.1-1

Source: SDS from Olin Winchester (synonyms: hard lead shot, shot, hard lead slugs, slugs, projectiles for shotgun cartridges) dated March 04, 2015: http://www.winchester.com/LEARNING-CENTER/SDS/Pages/Safety-Data-Sheets.aspx

Rifle and pistol ammunition cartridges contain a single projectile (bullet). The mass of the bullet is described in grains – there are 437.5 grains in an ounce. "Calibre" is the measure of a bullet's diameter; the higher the calibre, the bigger the bullet and, when used for hunting – it generally follows that the larger the bullet the larger the game it can be used to hunt. The calibre of the ammunition must match the calibre of the rifle/gun being used (the calibre is usually stamped on the barrel or receiver of the rifle). For example, .22 calibre 55-60 grain bullets can be used in a .22 calibre rifle (a 55 grain bullet has a mass of 3.6g), a 150 grain bullet has a mass of 9.7g, and a 220 grain bullet has a mass of 14.3g. Bullets of different size (grains) are selected based on the species being hunted e.g. a 150 grain bullet can be used to hunt white-tailed deer, a 220 grain bullet to hunt bears (see Figure 7).

Figure 7. Illustration of Bullet Calibres

Source: Bass Pro Shops: http://1source.basspro.com/index.php/component/k2/239-hunting-info/2495-use-this-rifle-caliber-chart-to-pick-the-ammo-for-hunting

Ammunition for muzzle-loaded rifles (also called black powder rifles) are lead round balls with .45 calibre rifled muzzleloaders able to rifle 137 grain roundball ammunition or 220 grain conical bullets and .50 calibre muzzleloaders able to fire 188 grain roundballs or 370 grain conical bullets. Muzzleloading ammunition is usually made from pure lead, but may also include a small percentage of antimony to confer hardness on the metal (see Figure 8).

Figure 8. Muzzleloading Rifle Round Balls Ammunition

Source: Cabela's: http://www.cabelas.com/product/Large-Caliber-Musket-Round-Balls/1200488.uts?slotId=0

Ammunition manufacturers combine multiple products on their SDS – the following extract from an SDS from Hornady includes muzzleloading round balls and indicates that the ammunition may be up to 100% lead. Suppliers of these muzzleloading round balls state that they are pure lead.[66]

[66] Midway USA: http://www.midwayusa.com/product/1165132904/hornady-muzzleloading-bullets-round-ball

Table 27. Composition of bullets, slugs, buckshot and muzzleloader projectiles (Manufacturer: Hornady)

CHEMICAL NAME(S)	CAS No.	RTECS No.	EINECS No.	%
Lead	7439-92-1	OF7525000	231-100-4	25-100
Copper	7440-50-8	GL5325000	231-159-6	0-45
Zinc	7440-66-6	Zh4810000	231-175-3	0-20
Antimony	7440-36-0	CC4025000	231-146-5	0-5
Aluminum	7429-90-5	BD0330000	231-072-3	0-7
Molybdenum Disulfide	1317-33-5	N/A	N/A	0-<1

Source: Hornady SDS dated 6/15/2015 for Bullets, Slugs, Buckshot and Muzzleloader Projectiles: http://www.hornady.com/assets/files/msds/Bullets_MSDS.pdf

Centrefire and Rimfire refer to the type of ammunition that a particular firearm can use. Rimfire cartridges contain their "priming compound" in the "rim" of the cartridge. The priming compound sparks to ignite the gunpowder within the cartridge case. The rim is precisely where the firing pin strikes when the user pulls the trigger. The powder charge sits directly in front of the priming compound, so ignition is very reliable. Rimfire cartridges are simply and easily constructed, use a relatively small amount of powder, and generally generate low pressures and low recoil. They are generally the smallest cartridges available. Rimfire firearms include the .22 long rifle (.22LR). Rimfire cartridges tend to be cheaper than centrefire cartridges but they cannot be remanufactured or reloaded. Once a rimfire cartridge has been fired, the priming agent in the rim is used up and, because that priming agent is not in a primer that can be removed and replaced with a fresh primer, there is no way to load them again with fresh powder and a bullet. Rimfire ammunition is a good choice for target practice, plinking and small game hunting.[67]

Centrefire cartridges use a primer that's a component of the overall cartridge construction – seen as a button-like fixture embedded in the center of the bottom of the cartridge. Primers for centrefire cartridges come in different sizes and power levels. Centrefire cartridges operate at significantly higher pressures than rimfire cartridges. This results in more recoil and more noise than rimfire cartridges, but the benefits are that centrefire rounds generate considerably higher velocities than rimfire, which is important when shooting at longer distances and for hunting. Centrefire cartridges can be reloaded (refers to using previously fired cases and reloading them with new primers, powder and bullets). Centrefire ammunition can be used for all the same uses as rimfire ammunition, but can also be used for large game and long-range shooting activities.[68]

Lead projectiles in rifle and handgun ammunition can be encapsulated in a copper jacket. The following table provides publicly available information on the composition of centrefire rifle/pistol cartridges from Federal Premium.[69]

Table 28: Composition of Centrefire rifle and pistol ammunition (all calibres) (Brand: Federal Premium)

Substance	**CAS**	**% (w/w)**
Lead	7439-92-1	30-60
Copper	7440-50-8	25-41
Zinc	7440-66-6	1-16

[67] National Sports Shooting Federation (NSSF): http://www.nssfblog.com/firstshotsnews/vocabulary-just-what-is-the-difference-between-rimfire-and-centerfire-ammunition/

[68] Ibid

[69] SDS: http://www.federalpremium.com/ammunition/rifle/family/power-shok/power-shok-rifle/308a

Nitrocellulose	9004-70-0	0.5-12
Nitroglycerin	55-63-0	<7
Antimony	7440-36-0	<3
Nickel	7440-02-0	<1
Zinc oxide	1314-13-2	<0.25
Graphite	7782-42-5	<0.25

Source: SDS from Federal Premium dated March 26, 2016: http://www.federalpremium.com/ammunition/rifle. Note that ammunition manufacturers combine multiple ammunition products onto single SDS likely to avoid disclosing details on the composition of individual ammunition products.

Olin Winchester provides the following composition information for centrefire jacketed lead bullets – this is the composition for the lead-core projectile only:

Table 29: Composition of Centrefire jacketed lead-core bullets (Manufacturer: Olin Winchester)

Substance	**CAS**	**% (w/w)**
Lead	7439-92-1	60-100
Copper/Zinc Alloy (brass)	Mixture	10-35

Source: SDS from Olin Winchester (synonyms: soft point bullets, full metal jacket bullets, power point bullets, jacketed hollow-point bullets) dated Feb 20, 2015: http://www.winchester.com/LEARNING-CENTER/SDS/Pages/Safety-Data-Sheets.aspx

Steel-jacketed lead core centrefire ammunition for vintage firearms (e.g. SKS – Soviet-designed semi-automatic rifle) is also available at low cost - this ammunition is referred to as "steel case 7.62x39mm Ammo"[70] – many shooting ranges do not allow this type of ammunition to be used due to potential for fire hazard as sparks can be generated on firing (BCWF, pers. comm. Jan 5, 2017).

Composition of rimfire ammunition:

The following table provides publicly available information on the composition of rimfire ammunition cartridges from Hornady (see Table 30).[71]

Table 30: Composition of Rimfire rifle ammunition with lead projectile (Manufacturer: Hornady)

Substance	**CAS**	**% (w/w)**
Lead	7439-92-1	25-60
Copper	7440-50-8	25-43
Zinc	7440-66-6	5-14

[70] E.g. see https://www.cheaperthandirt.com/product/century-international-arms-red-army-standard-762x39mm-fmj-bullet-brass-cased-122-grain-20-rounds-am2031b-787450377264.do?sortby=priceAscend&refType=&from=fn

[71] SDS: http://www.hornady.com/support/downloads/msds

Nitrocellulose	9004-70-0	6.5-13
Nitroglycerin	55-63-0	1-6
Antimony	7440-36-0	0-2
Zinc	7440-66-6	<0.25

Source: SDS from Hornady dated October 1, 2014: http://www.hornady.com/support/downloads/msds

Hornady also produces non-lead rimfire ammunition (NTX rimfire) – publicly available information on the composition of these non-lead rimfire cartridges is provided in the table below (see Table 31).

Table 31: Composition of Rimfire rifle ammunition with non-lead 'NTX' bullets (Manufacturer: Hornady)

Substance	**CAS**	**% (w/w)**
Antimony sulfide	7440-36-0	0-0.2
Barium nitrate	7440-39-3	<1
Copper	7440-50-8	25-75
Dibutyl phthalate	84-74-2	0-2
Diphenylamine	122-39-4	<1
Lead styphnate	12403-82-6	<1
Nitrocellulose	9004-70-0	5-20
Nitroglycerin	55-63-0	0-28
Tin	7440-31-5	1-15
Zinc	7440-66-6	10-20

Source: SDS for 'Varmint Express' rimfire cartridges loaded with 'NTX' bullets from Hornady: http://www.hornady.com/support/downloads/msds. Note that the small amount of lead (<1%) is associated with lead styphnate which is present in some primers.

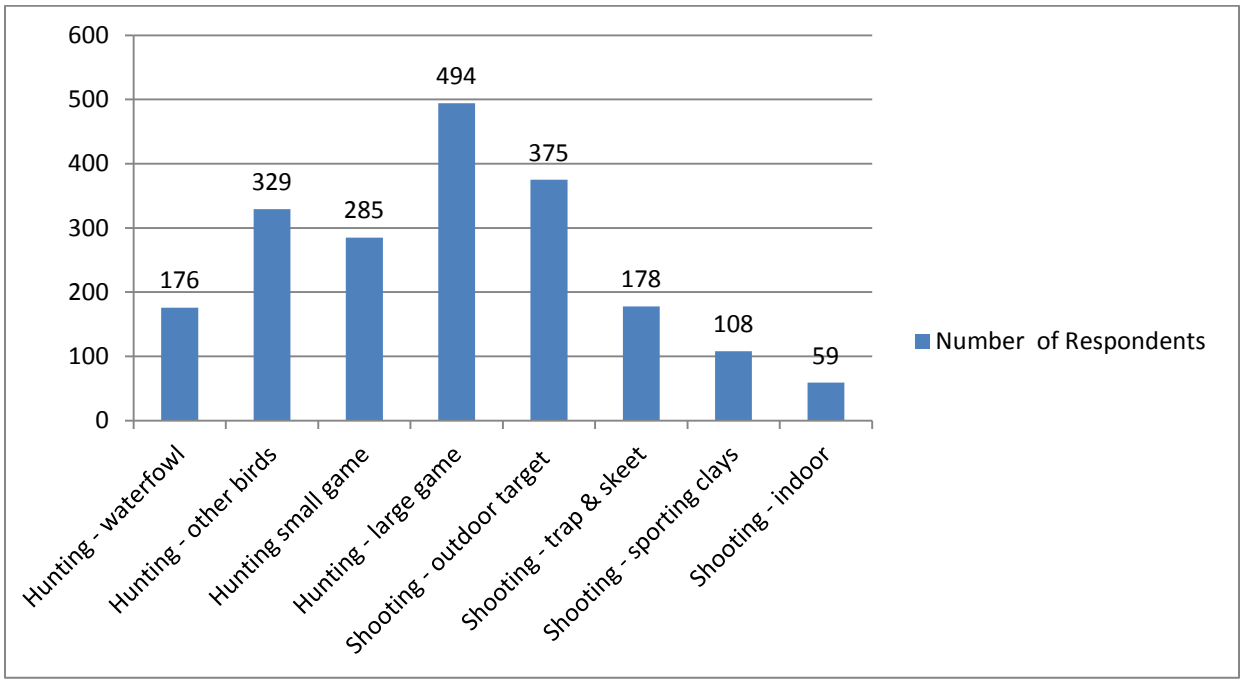
Available data on the number of cartridges (and/or the mass of projectiles) used in ammunition in Canada each year must be adjusted to take into account lead content.

Based on the above composition data we assume that lead shot/slugs used in shotgun cartridges contain 99% lead (w/w) as stated on Olin Winchester's SDS, and that jacketed lead-core bullets contain 90% lead (since Olin Winchester's SDS for jacketed lead-core bullets indicates that the copper/zinc alloy component can be as low as 10% (w/w)).

3.2 Estimate of Ammunition used in Canada

The electronic hunter survey (2017) requested details on the type of ammunition used for hunting and sport shooting and included the question: "What type and size of ammunition do you typically use for each activity? Please specify if the ammunition is lead or non-lead." In total, 512 individuals answered this question – the activities these individuals participated in are summarized in Figure 9 below. Note that most individuals participated in multiple activities and there was significant overlap between hunting and sport shooting activities, for example, >90% of the respondents reported hunting large game and 78% of these hunters also reported that they participated in outdoor target shooting.

Figure 9. Hunter Survey (2017) Respondents reported participating in the following activities using ammunition



Source: Hunter survey (2017) – total respondents to this question: 512. Many individuals participate in multiple hunting/shooting activities. See survey in Appendix 2.

Hunters of waterfowl must use non-lead ammunition and >97% of responding waterfowl hunters reported using steel shot, with ~1% reported using tungsten and <1% reported using bismuth shot. Hunters that hunted birds outside the legislated non-lead hunt mainly hunted with lead ammunition, with ~1% of these hunters using non-lead ammunition (mostly steel shot; one hunter reported using tungsten). More than 99% of hunters used lead ammunition when hunting small game (predominantly .22 calibre rifle bullets or lead shotgun cartridges) with only 2 hunters indicating they used '.22 non-lead rabbit' (alternative material not specified) and 'copper centrefire'. Most large game hunters reported using lead ammunition (>96%) with approximately 3% using solid copper bullets when hunting large game. The most common non-lead ammunition reported for large game was .308 calibre solid copper bullets; range of bullet grains reported: 150-180 grain (Barnes TSX). More than 99% of respondents participating in outdoor target shooting reported using lead ammunition – and those using non-lead reported using solid copper bullets. Approximately 99% of participants in trap & skeet and sporting clays indicated that they used lead shot and several respondents indicated that they were using both lead shot and non-lead shot (steel). One respondent indicated that they were using lead shot but could switch to non-lead. More than 99% of respondents that participated in indoor target shooting reported using lead ammunition (Hunter Survey, 2017).

The hunter survey also requested details on the quantity of ammunition used per year i.e. 'In the last 12 months how many rounds/shots did you discharge for each activity you participated in?' The annual quantity of rounds used by hunters and sports hooters in each activity varied widely depending on the individual. On average,

hunters that responded to the survey used ~60 rounds per year hunting waterfowl, ~30 rounds per year hunting other birds, ~30 rounds per year hunting small game, and 5 rounds per year hunting large game. Participants in outdoor target shooting reported using an average of ~400 rounds per year (range reported: 10 rounds to 10,000 rounds per person per year). Participants in trap and skeet reported using an average of ~600 rounds per year (range reported: 25 rounds to 9,000 rounds per person), and participants in sporting clays reported using an average of ~500 rounds per year (range reported: 20 rounds to 3,000 rounds). The average quantity of rounds used in indoor target shooting was ~1250 rounds per year per person (range reported: 10 rounds to 7,000 rounds). Respondents to the hunter survey typically participated in multiple hunting and sport shooting activities (Hunter Survey, 2017).

It appears that the current market for ammunition in Canada (excluding military applications) is predominantly lead. Stakeholders that provided feedback for this study (including ammunition manufacturers, importers, distributors, retailers and end-users including shooting ranges who provided input) all consistently stated that lead continues to dominate the market and that the only real market for non-lead ammunition is the legislated market under the *Migratory Birds Convention Act*. Uses of non-lead ammunition outside of the legislated market were said to be 'incidental'.[72] The results of the hunter survey (2017) also indicate that the uses of non-lead ammunition in Canada are largely confined to hunting waterfowl, with uses outside the legislated non-lead hunt being minimal.

Overall, there has been significant reluctance from stakeholders across Canada to provide information for this study based on a general suspicion that any information provided will be used to restrict uses of lead ammunition and/or result in increased gun control.

Our analysis is therefore largely restricted to the use of publicly available data, with some responses from the stakeholder surveys, to develop estimates of the total uses of lead in ammunition. These could be refined further if further data become available with continued survey and stakeholder engagement efforts. In particular, it would be most useful to have detailed sales data from ammunition manufacturers, importers, and retailers.

Since the only significant market for non-lead ammunition in Canada currently is the legislated market under the *Migratory Birds Convention Act* it is possible to estimate the amount of non-lead ammunition used in Canada using: (1) data on migratory bird harvest numbers, (2) information on the typical type and size of ammunition used to hunt migratory birds, and (3) assumptions regarding the typical number of shots fired for each migratory bird reported.

3.2.1 Migratory Bird Harvest Data

Canadian Wildlife Service (CWS) maintains a harvest database[73] for migratory bird species. This database offers a query feature that enables users to retrieve hunting and harvest data for all migratory game bird species found in Canada. These data are derived from harvest surveys[74]run annually by CWS. The CWS database provides on-line access to data that have been edited and analyzed. A general description of survey design can be found on the CWS National Harvest Survey Design page[75]. CWS provides the following disclaimer for the survey data: "The National Harvest Survey (NHS) is a large-scale survey of migratory game bird hunting in Canada. It is coordinated by Canadian Wildlife Service at the National Wildlife Research Centre in Ottawa. This Web site offers data on migratory game bird harvest and hunting activity occurring in Canada only."

CWS National Harvest Survey Design:

The National Harvest Survey is the joint name for two surveys sent annually to a sample of purchasers of the Migratory Game Bird Hunting Permit (MGBHP), introduced by the federal government in 1966. These two surveys are the Harvest Questionnaire Survey (HQS) and the Species Composition Survey (SCS). Data from

[72] Pers. comm. ammunition manufacturer with US-based production and sales office in Canada manufacturing both lead and non-lead ammunition
[73] CWS Harvest Database for Migratory Birds: http://www.ec.gc.ca/reom-mbs/enp-nhs/index.cfm?do=dis&lang=e
[74] National Harvest Surveys (CWS): http://www.ec.gc.ca/reom-mbs/default.asp?lang=En&n=CFB6F561-1
[75] National Survey Design (CWS): http://www.ec.gc.ca/reom-mbs/default.asp?lang=En&n=0D83C918-1

these and other CWS surveys are used to assess the status of migratory game bird populations in Canada, their productivity, survival rates, and amount of harvest they can sustain.

The *Harvest Questionnaire Survey* is sent in the fall to approximately 45,000 randomly chosen hunters. It is used mainly to estimate the harvest of migratory game birds and hunting activity in Canada. A smaller group of hunters participates in the Species Composition Survey (or Wing and Tail Survey). Data from this survey are used, in combination with Harvest Questionnaire Survey data, to estimate the numbers that are hunted of each species of waterfowl and other game bird species, as well as the age and sex composition of the harvest.

All numerical results tabulated from a survey (e.g., means and proportions) are referred to as estimates. This is because the results are collected from only a sample of the individuals in the population, and a sample is not identical to the total population. A standard error is a measure of the precision of an estimate and describes how much the estimate may differ from the unknown true population value. It itself is an estimate derived from the results of the survey. The smaller the standard error, the more likely the estimate is close to the true value. If the sample size is large (greater than 30), the standard error can be used to derive confidence intervals. As a rule of thumb, the true value has a 95 percent confidence level of being within plus or minus two standard errors of the estimate.

Note that the standard error describes only one source of error in the estimates. It reflects the sampling error caused by selecting only a portion of the population to represent the entire population. Other sources of error exist that may affect the accuracy of the estimate. These include non-response bias, respondents not answering the questions correctly, and data entry errors. The non-sampling error is of unknown magnitude and can only be contained through careful survey design.

Data on the number of birds harvested with non-toxic shot as required by the *Migratory Birds Convention Act* can be downloaded for each Province from the CWS National Harvest Survey Database.[76] The number of birds harvested with non-toxic shot can be estimated using the CWS data (see section 3.2.2).

3.2.2 Ammunition used for Migratory Bird Hunting

In most areas of Canada, it is illegal to hunt migratory game birds with the use of a rifle, a shotgun loaded with cartridges containing a single bullet, or with a crossbow. However, exceptions to this regulation do exist. For example, a resident of the Northwest Territories who is not required to hold a migratory game bird permit may, within the Northwest Territories hunt a migratory bird by the use of a shotgun or a rifle with a calibre of not more than 0.22 inches.[77] Hence the legislated non-lead hunt in Canada primarily uses shotgun cartridges.

Shotgun cartridges used for the legislated non-lead hunt typically contain steel shot and the cartridges used typically contain an average of 1.25 oz of shot (35.4g).[78] The bulk of steel shot used by North American manufacturers is imported from China.[79] US shotgun cartridge manufacturer also import several types of tungsten alloyed shot but this is incidental to the amount of steel shot sourced from China.[80] Another non-lead alternative that is used is bismuth but this option currently forms <1% of the non-toxic ammunition market.[81]

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[76] Where there were exceptions for specified species e.g. woodcock can be hunted with lead shot in Ontario, Quebec, Manitoba, New Brunswick, and Nova Scotia; lead shot can be used to hunt band-tailed pigeons and mourning doves in BC, and; lead shot can be used to hunt murres (turrs) in Newfoundland and Labrador. Harvest numbers for these species were removed from the estimations for the use of non-toxic shot i.e. it was assumed that if a species could legally be hunted with lead shot it would be.

[77] https://www.ec.gc.ca/rcom-mbhr/default.asp?lang=En&n=F566470E-1

[78] The shot loads used can vary from 7/8 oz to 1 9/16 oz; however 1 1/4 oz (1.25 oz) is the typical/average shot load used for waterfowl. E.g. see 'Best Duck Loads: How to Pick the Right Shell for the Right Bird": http://www.outdoorlife.com/blogs/gun-shots/best-duck-loads-how-pick-right-shell-right-bird; Example listing that illustrates the range of steel shot loads available: http://kentgamebore.com/waterfowl-loads/fasteel-waterfowl.html; also see Humburg et al (1982) Shotshell and shooter effectiveness: Lead vs Steel shot for duck hunting. Wildl. Soc. Bull. 10; 121-126

[79] US Cartridge Manufacturer, pers. comm. 2016. Note that the steel shot is imported from China to the US for cartridge manufacturing. The completed cartridges are then imported from the US to Canada and would be captured under 'US ammunition imports'

[80] US shotgun cartridge manufacturer pers. comm. Nov 2016

[81] Ibid

Data on the number of birds harvested with non-toxic shot as required by the *Migratory Birds Convention Act* was downloaded for each Province from the CWS National Harvest Survey Database[82]. The analysis was conducted on a province by province basis initially and then the numbers combined to generate an estimate for Canada. In developing the estimate, we took into account differing requirements between provinces and territories regarding the species that can be hunted with lead vs non-toxic shot. For example, in BC, non-toxic shot must be used to hunt migratory birds except for band-tailed pigeons and mourning doves - whereas in QC non-toxic shot must be used for hunting migratory birds including mourning doves, but hunting woodcocks is excluded from the non-toxic shot requirement in QC. Hence, the harvest numbers for mourning doves and band-tailed pigeons were not included in the estimate of non-toxic shot used in BC – it was assumed that if hunters could use lead shot for these species they would. Whereas the harvest numbers for mourning doves from QC were included in the estimate of non-toxic shot use in Quebec, but woodcock harvest numbers in QC were assumed to be due to lead shot. To estimate the quantity of cartridges used in the migratory bird hunt, and hence the quantity of non-toxic shot used in Canada each year, we assumed that 1, 3 or 6 shotgun cartridges could be fired for each recorded kill. The estimate of 3 to 6 shots per kill assumes that some shots will miss the target. In addition, even when the target is struck, extra shots could be required to kill struck and downed birds. This estimate recognizes that shotguns used for waterfowl hunting must not contain more than three cartridges, so reloading the gun may be necessary. Scheuhammer and Norris (1995) assumed that up to 6 shots could be used for each duck kill, and that an average of 54 rounds were discharged by an average Canadian waterfowl hunter per year bagging 8-10 birds. Our recent hunter survey indicated that waterfowl hunters used an average of ~60 rounds per year (Hunter Survey, 2017) which is similar to the average number of rounds from Scheuhammer and Norris (1995).

The harvest numbers and calculations for each province are provided in a separate excel spreadsheet. A summary of the results for Canada is provided in Table 32 below.

[82] Where there were exceptions for specified species e.g. woodcock can be hunted with lead shot in Ontario, Quebec, Manitoba, New Brunswick, and Nova Scotia; lead shot can be used to hunt band-tailed pigeons and mourning doves in BC, and; lead shot can be used to hunt murres (turrs) in Newfoundland and Labrador. Harvest numbers for these species were removed from the estimations for the use of non-toxic shot i.e. it was assumed that if a species could legally be hunted with lead shot it would be.

Table 32. Migratory Bird Harvest in Canada 2011-2015: Number Non-Lead Cartridges Used

Migratory Birds Hunting: Estimate of Legislated Non-Lead Harvest				**Number of cartridges of non-toxic shot used (#):**		
Year	Prov	Citizenship	Variable Code	Estimate # non-lead cartridges used (1 shot per kill)	Estimate # non-lead cartridges used (3 shots per kill)	Estimate # non-lead cartridges used (6 shots per kill)
2011	ALL	All hunters	Legislated non-lead hunting	2,306,555	6,919,665	13,839,330
2012	ALL	All hunters	Legislated non-lead hunting	2,210,935	6,632,805	13,265,610
2013	ALL	All hunters	Legislated non-lead hunting	2,429,862	7,289,586	14,579,172
2014	ALL	All hunters	Legislated non-lead hunting	2,341,655	7,024,965	14,049,930
2015	ALL	All hunters	Legislated non-lead hunting	2,192,730	6,578,190	13,156,380
Average 2011-2015				2,296,347	6,889,042	13,778,084

The number of cartridges used in the legislated non-lead hunt was then used to calculate the total mass of shot (primarily steel shot) used assuming that the shotgun cartridges used contained on average 35.4 g of shot (see following Table 33).

Table 33. Migratory Bird Harvest in Canada 2011-2015: Mass of Non-Lead Shot Used (Tonnes)

Year	**Estimated mass of shot in non-lead cartridges (1 shot per kill) tonnes**	**Estimated mass of shot in non-lead cartridges (3 shots per kill) tonnes**	**Estimated mass of shot in non-lead cartridges (6 shots per kill) tonnes**
2011	81.7	245.0	489.9
2012	78.3	234.8	469.6
2013	86.0	258.1	516.1
2014	82.9	248.7	497.4
2015	77.6	232.9	465.7
Average 2011-2015	81.3	244	488

Going forward in the analysis we have used the estimate based on 3 shots per kill as the average scenario. The 1 to 6 shots per kill estimates can be used to frame upper and lower bounding estimates to take into account the uncertainty in the estimates given the lack of data obtained from major stakeholders in the ammunition market.

Scheuhammer and Norris (1995) also noted that 26% of hunters in Canada hunted waterfowl and 48% hunted other game birds. Of the respondents to the recent hunter survey ~30% of indicated that they hunted waterfowl, ~60% hunted other birds, ~50% hunted small game, and ~90% hunted large game (Hunter Survey, 2017). The most detailed harvest data available is for migratory birds from the CWS database and there is less comprehensive information available for hunting harvest numbers for other species. The availability of data on the hunting of other species varies significantly on a province by province basis. The following section uses available harvest data for other species (outside of the legislated non-lead hunt) to estimate ammunition use for hunting other game animals.

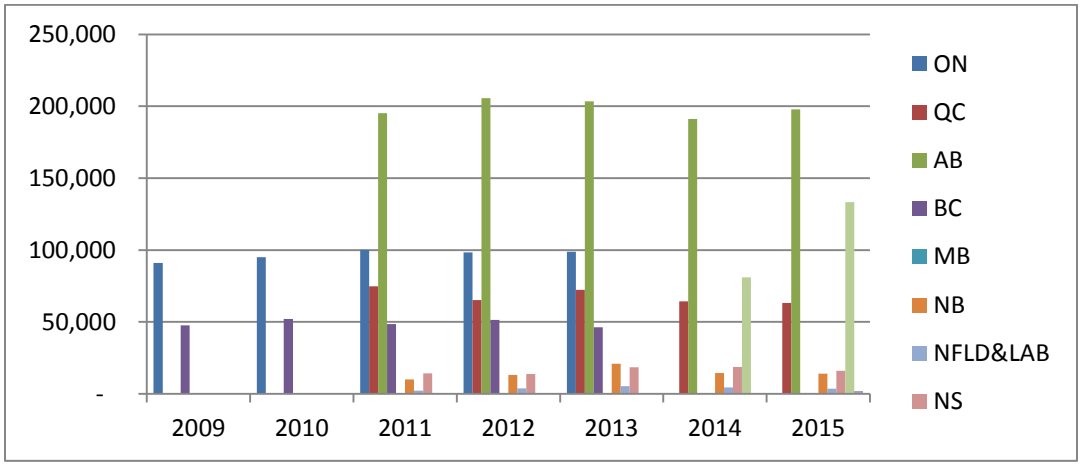
3.2.3 Ammunition for Hunting outside the legislated non-lead hunt

Available harvest data from each province and territory were downloaded from the provincial/territorial authorities responsible for hunting activities in the province/territory. For example, hunting harvest data from the Ontario Ministry of Natural Resources and Forestry provides numbers for the annual harvests of white-tailed deer, elk, moose, black bear and wild turkey (there is no additional data for small game (e.g. rabbits, hares, groundhogs etc.), other upland birds, or wolves/coyotes). Since woodcock can be hunted with lead in Ontario the harvest numbers for woodcock from the CWS database were included in the estimate of lead ammunition uses for Ontario. The Alberta Ministry of Natural Resources also provides harvest numbers for big game species (white-tailed deer, mule deer, moose, elk, antelope, black bear) and more upland birds than Ontario (wild turkey, pheasant and grouse). QC and BC also provide harvest numbers for big game species but limited data for upland birds. Manitoba does not provide any hunting harvest data hence the only relevant data available for MB is the woodcock harvest numbers from the CWS database. Woodcock can be hunted with lead ammunition in MB. Similarly no hunting harvest data for Newfoundland and Labrador were available hence the only relevant data available for this province are the murre harvest numbers from the CWS database – as murres can be hunted with lead ammunition. No hunting harvest data for any species was available for Nunavut, NWT, or PEI. In addition, hunting data, where it was available, was not consistently available for each year for the 2011-2015 from each province.

Given that hunting harvest numbers outside the legislated non-lead hunt cover only a select group of species, with variable coverage by province, the estimates developed should be considered an underestimate of the total amount of ammunition used in hunting.

Figure 10 provides a summary of the number of animals harvested by province based on available harvest data. These indicate that hunting activity across Canada has remained fairly steady during the 2011-2015 time period.

Figure 10. Number of Game Animals Harvested and Reported by Province



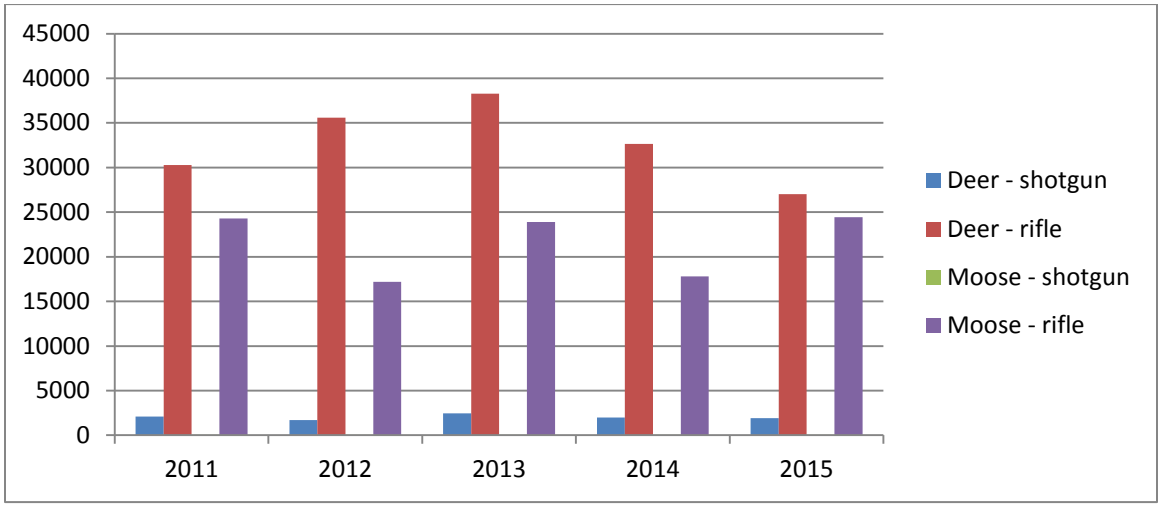
Notes: Data for ON, BC only available for 2009-2013; for QC, AB, MB, NB, Nfld & Lab, NS for 2011-2015; for SK 2014-2015 only, Yukon 2015 only.

Similar to the approach used to estimate the number of cartridges used to harvest migratory birds we assumed that 1, 3 or 6 shots could be used for each reported animal kill.

The ammunition used for hunting depends on a number of factors including the species being hunted and the guns available to the hunter, restrictions on the use of certain firearms in certain areas and to hunt certain species, and the preferences of the hunter. Animals may be hunted with rifles or shotguns, and in general, larger species are hunted with larger calibre bullets.

Quebec is the only province that provides hunting harvest data broken down by the type of weapon used: shotgun, rifle or bow. The animals killed by bow were not included in the subsequent estimates of ammunition used for hunting in this Province. The number of animals killed by shotgun vs rifle in QC for 2011-2015 is provided in Figure 11 below.

Figure 11. Number of White-tailed deer and Moose harvested in Quebec: Shotgun vs Rifle Uses[83]



As illustrated in Figure 11 large game animals are primarily hunted with rifles.

In order to estimate the total mass of projectiles used in hunting ammunition we used available information on typical bullet grains, or shotgun loads that can be used to hunt each game animal. These assumptions are summarized in Table 34 below.

[83] Quebec Ministère des Forêts, de la Faune et des Parcs: https://www.mffp.gouv.qc.ca/english/wildlife/statistics/index.jsp#hunting

Table 34. Typical ammunition used to hunt game animals with reported harvests

Game Species	Typical bullet grain used	Lowest typical grain bullet: lead mass (g)	Highest typical grain bullet: lead mass (g)	Typical shotgun load	Shotgun load: lead mass (g)
Deer	130-150	8.4	9.7	1oz	28.4
Moose/Elk/Caribou	156-160	10	10.4	1.125 oz (heavy game load)	32
Bear	220	14.3	14.3	1.125 oz (heavy game load)	32
Cougar/Wolf	80	5.2	5.2		
Wild turkey	25-45	1.6	2.9	1 7/8 oz (turkey load)	53.25
Woodcock / Pheasant				1.5 oz	35.4
Grouse / Hare				1.125 oz	32

The number of animals harvested, the typical lead mass per cartridge used for each species, and the fact that up to 6 shots could be fired on average for each kill was used to develop estimates of lead use in hunting for each province providing hunting data. An example of the output is provided below for Ontario (see Table 35).

Table 35. Reported hunting harvest in Ontario (excl. migratory birds that must be hunted with non-lead): Estimated mass of lead projectiles used

Year	# cartridges used (1 per kill)	# cartridges used (3 per kill)	# cartridges used (6 per kill)	Total Lead (1 cartridge per kill) (tonnes)	Total Lead (3 cartridge per kill) (tonnes)	Total Lead (6 cartridge per kill) (tonnes)
2009	90,935	272,805	545,610	1.49	4.46	8.92
2010	95,148	285,444	570,888	1.64	4.91	9.83
2011	100,088	300,264	600,528	1.73	5.20	10.39
2012	98,377	295,131	590,262	1.56	4.69	9.38
2013	98,783	296,349	592,698	1.53	4.58	9.17

A combined total for all provinces is provided in Table 36.

Table 36. Reported hunting harvest in Canada (excl. migratory birds that must be hunted with non-lead): Estimated mass of lead projectiles used

# cartridges used (1 per kill)	# cartridges used (3 per kill)	# cartridges used (6 per kill)	Total lead (1 cartridge per kill) (tonnes)	Total lead (3 cartridge per kill) (tonnes)	Total lead (6 cartridge per kill) (tonnes)
601,215	1,803,645	3,607,290	13.5	40.6	81.2

We therefore estimate that 40 to 80 tonnes of lead are used in hunting (outside of the legislated non-lead hunt) based on reported harvest numbers and assuming 3 to 6 shots per reported kill.

The major non-military areas in which ammunition is used are hunting (migratory birds legislated non-lead hunt and hunting outside the legislated non-lead hunt), sports shooting (e.g. target shooting, trap and skeet, sporting clays), and law enforcement. The following section provides publicly available data on ammunition purchases for law enforcement activities in Canada.

3.2.4 Ammunition for Law Enforcement

Given the reluctance of stakeholders at all levels of the supply chain to provide data for a government study on ammunition (including major manufacturers, importers, distributors, and end-users) we must rely largely on publicly available information. We are able to estimate the amount of lead used in hunting using reported harvest data (see section 3.2.3). In addition, we have been able to gather data on ammunition purchases by the RCMP, Correctional Services Canada (CSC), other federal enforcement activities, and some police forces and have used these data to provide an estimate of potential uses in enforcement. For example, the following order for a total of 7,545,000 cartridges in 2013 by the RCMP provided technical specifications and all cartridges contained projectiles primarily made of lead (see Table 37).

Table 37: Example of ammunition purchases by RCMP in 2013 (Order #M077-13G305/A)

# Cartridges	Bullet Grain	Lead (g)	Description
5,370,000	147	9.6285	FMJ 9x19mm encapsulated lead core, reduced hazard, pistol
1,967,500	147	9.6285	JHP 9x19mm Winchester, Federal or Remington
122,500	150	9.825	.308 Winchester PSP
85,000	147	9.6285	FMJ 9x19mm

The following is an example of ammunition purchases by Correctional Services Canada in 2016 which totals 760,000 cartridges and included jacketed hollow point (JHP) 147 grain lead bullets as well as shotgun cartridges each containing 1.25 oz of lead buck shot for delivery over 3 years 2017-2019 (see Table 38).

Table 38: Example of ammunition purchases by CSC in 2016 for delivery to various facilities across Canada in 2017-2019 (#2110-161858/001/BK)

# Cartridges	Bullet Grain or oz shot	Lead (g)	Description
360,000	147	9.6285	JHP 9x19mm 147 gr
150,000	1 1/4 oz buck shot	35.436875	12 Gauge shotgun No. 4 buck shot
150,000	1 1/4 oz buck shot	35.436875	12 Gauge shotgun No. 4 buck shot
100,000	1 1/4 oz buck shot	35.436875	12 Gauge shotgun No. 4 buck shot

A total of 791,000 cartridges (shotgun cartridges and rifle/pistol ammunition) were also purchased by Public Works Government Services Canada (PWGSC) for Environment Canada Enforcement Branch, the Department of Fisheries and Oceans – Conservation and Protection Branch, Parks Canada – Law Enforcement Branch in 2012 to cover ammunition requirements for 2012 to 2016 indicating average annual uses of ~197,750 per year. The specifications for this ammunition (solicitation number E60BK-120002/A) indicate that virtually all this ammunition contains lead projectiles. Some 147 grain bullets were required to be 'reduced hazard / lead free' but the specifications for these indicated that encapsulated lead core bullets could be provided.

In total, available data indicates that 4,816,250 cartridges were purchased for law enforcement activities across Canada containing 119 tonnes of lead.

3.2.5 Ammunition for Shooting Sports

As stated above, given the reluctance of stakeholders at all levels of the supply chain to provide data for a government study on ammunition (including major manufacturers, importers, distributors, and end-users) we

must rely largely on publicly available information to estimate uses of ammunition in shooting sports. The main non-military uses of ammunition in Canada are hunting, law enforcement, and shooting sports. We have developed estimates of uses in hunting and law enforcement and we know that 375,000,000 cartridges are imported on average into Canada each year.

NRCan can only provide us with the total cartridge number imported but no breakdown of the cartridges by type. Available import data based on HS Codes from CIMT provides a little more detail on the types of ammunition imported – but these import data covers only ~25% of the NRCan imports and the import descriptions are still very limited.

For example, import data from CIMT give details of pistol/rifle ammunition vs shotgun ammunition Based on available HS code data on imports to Canada from the US the following estimates can be made:

Imports of Rifle/Pistol Ammunition (HS 9306.30.4120): In 2015, 69,595,950 cartridges for rifle/pistol were imported from the US into Canada. Based on average 147-150 grain rifle bullet projectile which has a mass of ~9.7 g and that 69,595,950 cartridges for rifle/pistol = total projectile mass of ~675 tonnes imported from US in 2015. This HS code excludes .22 calibre ammunition.

It is interesting to note that CIMT provides no data for imports of HS 9306.30.4110 which covers 'Cartridges other than Shotgun - with projectile - for Rifle/Pistol - .22 cal. Whereas .22 caliber rifles are popular in Canada and the US and US-manufactured ammunition for .22 calibre rifles is readily available at all major retailers in Canada.

Imports of Shotgun Cartridges (HS 9306.21.0000): In 2015, 21,842,143 shotgun cartridges were imported into Canada from the US. Although imported in smaller numbers than rifle/pistol cartridges shotgun cartridges contain more mass of shot per cartridge. Based on an average of 32 g of shot per cartridge and 21,842,143 cartridges imported it is estimated that the total mass of shot imported in these imported cartridges in 2015 was ~699 tonnes.

We requested data from shooting ranges and received some information but insufficient data to estimate total uses of ammunition on ranges or to provide details on the number of shotgun cartridges vs rifle vs pistol cartridges used annually.

We used the following equation to estimate uses of ammunition in shooting sports:

Eq: *SS = (I+D) - (H + LE)*

Where;

SS = total projectile mass used in shooting sports (tonnes)

I = total projectile mass in imported ammunition (tonnes)

D = reported mass of domestically manufactured lead shot (tonnes)

H = mass of projectiles used in hunting ammunition (tonnes)

LE =mass of projectiles used in law enforcement (tonnes)

To develop the estimate for total lead uses on shooting ranges we used the total number of annual cartridge imports from NRCan (375 million) and the expected average projectile mass per cartridge to calculate total mass of imported projectiles (5391 tonnes), we then added reported domestic production of lead projectiles (95 tonnes) to this total (5486 tonnes of imported and domestically produced projectiles; of this total 5242 tonnes[84] are expected to be lead projectiles) and then removed the estimated number of cartridges used for hunting and law enforcement. The remaining cartridges, estimated to contain a total mass of projectiles of 5082 tonnes, are assumed to be used primarily for shooting sports. The vast majority of the ammunition used in shooting sports is traditional lead ammunition.

Available market research data, and input from stakeholders, indicates that there has been increased participation in shooting sports in recent years. For example, target shooting participation in the US increased

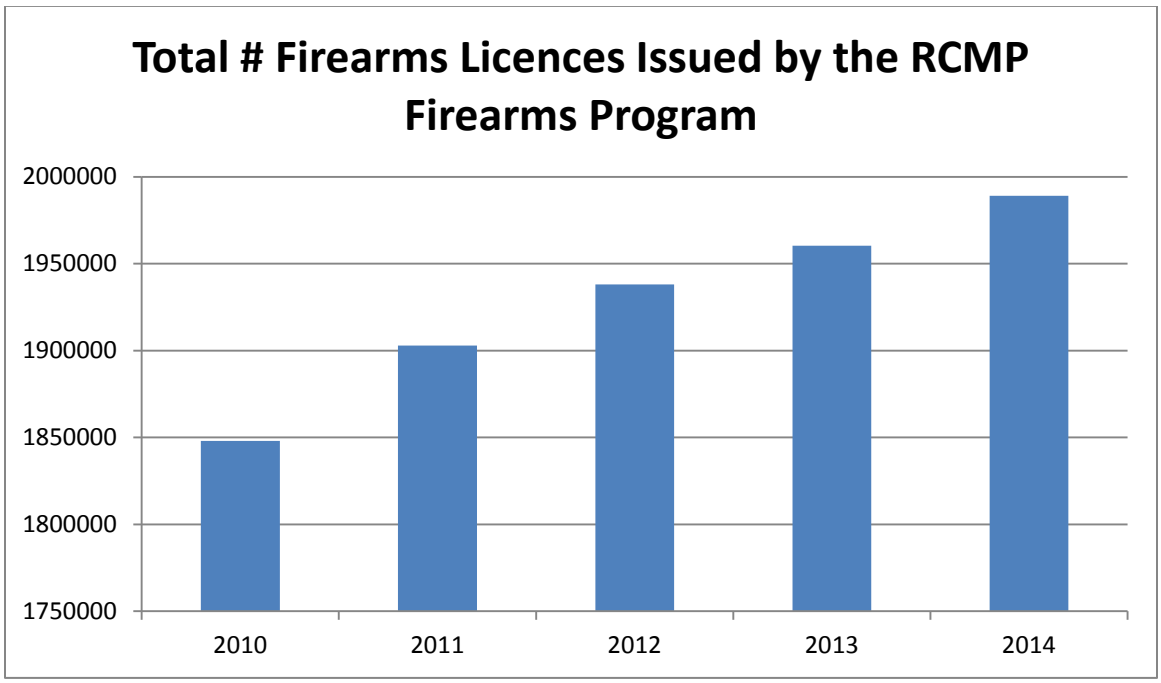
[84] 5486 tonnes total projectiles minus shot used in legislated non-lead hunt of 244 tonnes (3 shots per kill)

more than 10% in 2012 compared to 2011[85] Stakeholders involved with shooting ranges in Canada indicated that their ranges have seen double-digit increases in shooting sports participation year after year in recent years.[86] Consistent with this picture is the fact that the number of firearms licenses issued by the RCMP have increased in recent years (see section 3.2.5.1), whereas participation in hunting has not shown an increase.

3.2.5.1 Firearms licences

The total number of firearms licences issued by the RCMP has increased steadily over the period 2010-2014 (latest data available) – see Figure 12.

Figure 12. Trends in the Number of Firearms Licences Issued in Canada 2010-2014



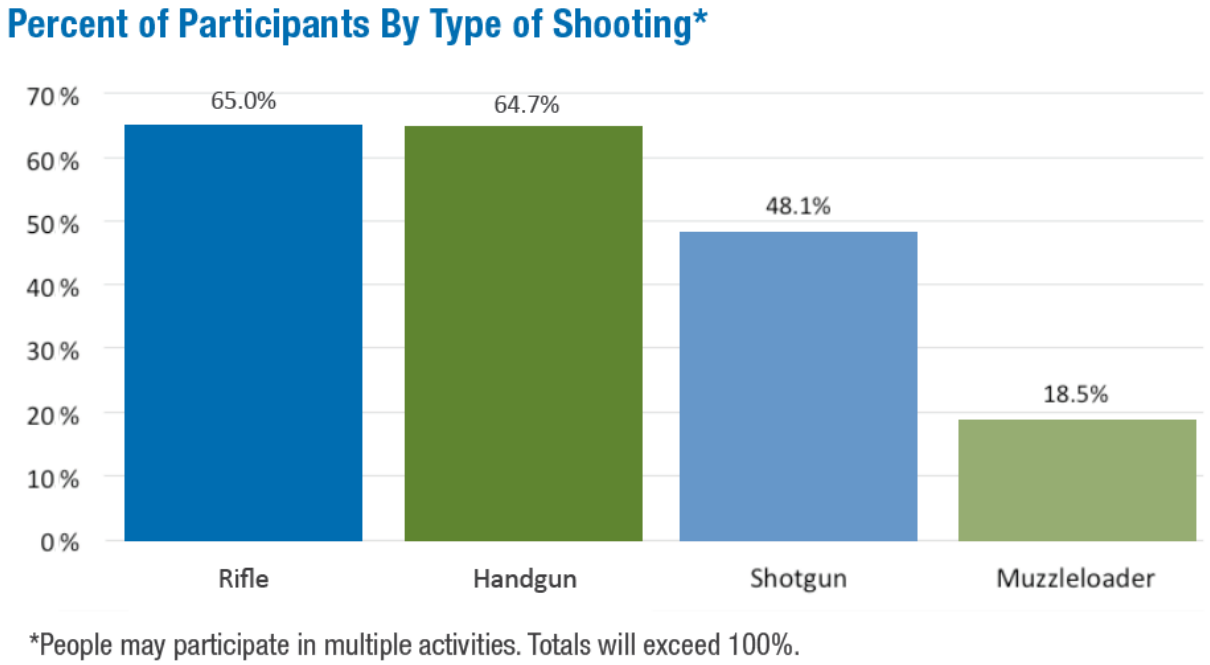
Source: RCMP http://www.rcmp-grc.gc.ca/cfp-pcaf/facts-faits/index-eng.htm (Consulted in October 2016)

The increase in firearms licences issued by the RCMP over the 2010-2014 period is consistent with the reports from shooting ranges and other stakeholders that shooting sports have become increasingly popular over the last 5 years coincident with evidence of increasing ammunition sales.[87] Note the number of animals hunted has not shown an increase over this period based on reported harvest data – indicating that increased firearms licences are probably associated with shooting sports participation and not hunting participation.

Some additional data on shooting sports participation are available from other jurisdictions. Participation levels for target shooting with rifles, handguns, shotguns, and muzzleloaders are available for the US (see Figure 13-14 below). Participation information of this level of detail is not available for Canada but some overall participation patterns and trends in the US may be reasonably representative of the situation in Canada. For example, some trends observed in the US, such as increased participation levels in the shooting sports over the last 5 years, have also be noted in Canada.[88]

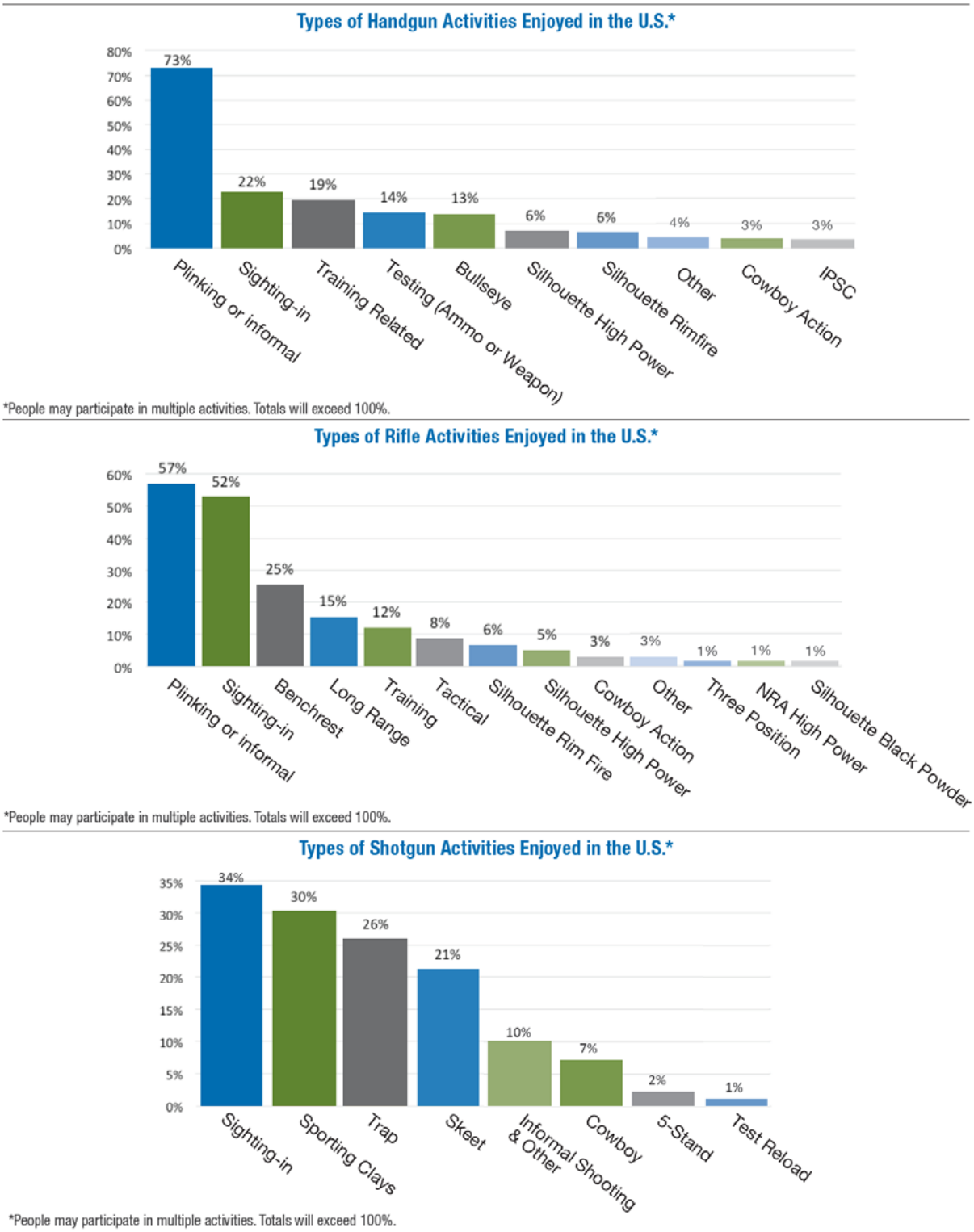
[85] Gun and Ammunition Manufacturing 2016. First Research Industry Profile.
[86] Shooting range managers, pers. comm. 2016/2017 – by phone
[87] Ammunition distributor pers. comm. 2016
[88] Based on responses of shooting ranges to requests for information.

Figure 13. Percent of Participants by Type of Shooting Sport (US)



Source: Southwick Associates 2013. Target Shooting in America. Produced for the National Shooting Sports Foundation (NSSF)

Figure 14. Types of Shooting Activities (US): Handgun activities, rifle activities, muzzleloader activities

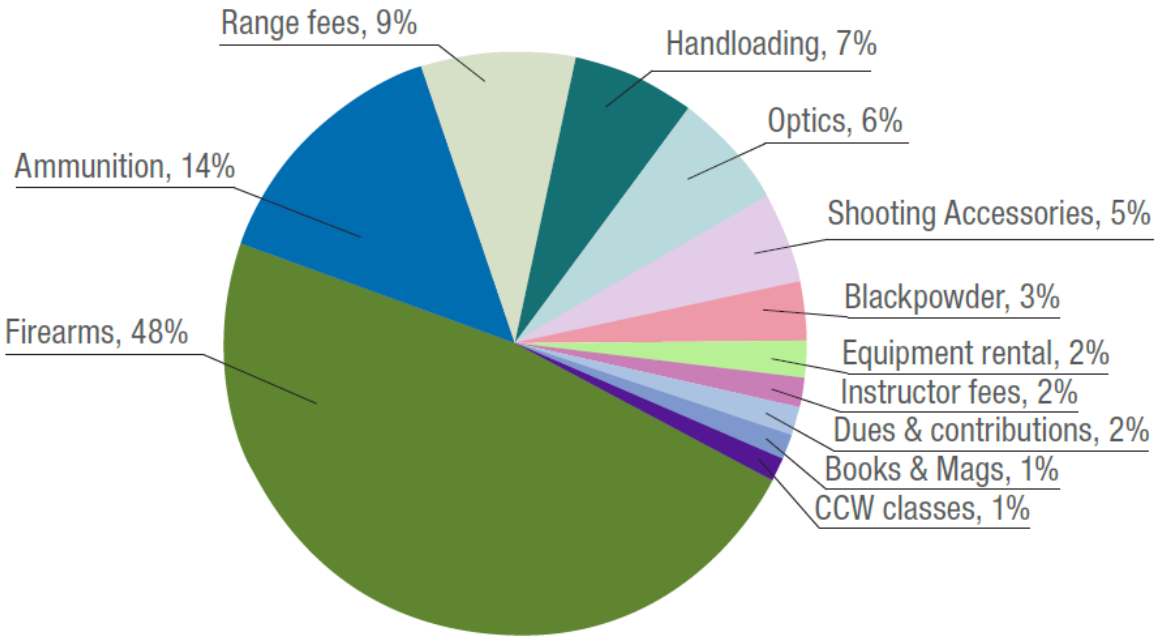


Participation in target shooting by state in the US roughly parallels each state's population.[89] The average shooter in the US spent 22 days shooting per year, however, in some states the average number of days spent shooting at the range were higher at 35-38 days per year (i.e. Oregon, Arizona, and Nebraska).

Spending on target shooting can be categorized into two types – equipment and trip-related expenditures. Most of the expenditures by target shooters are on equipment, accounting for 82% of all target shooting-related spending.[90]

Participants in shooting sports spend 14% of expenditures directly related to shooting sports on ammunition (see Fig 15 below, based on US data)

Figure 15. Target Shooting Equipment Expenditures



Source: Southwick Associates 2013. Target Shooting in America. Produced for the National Shooting Sports Foundation (NSSF)

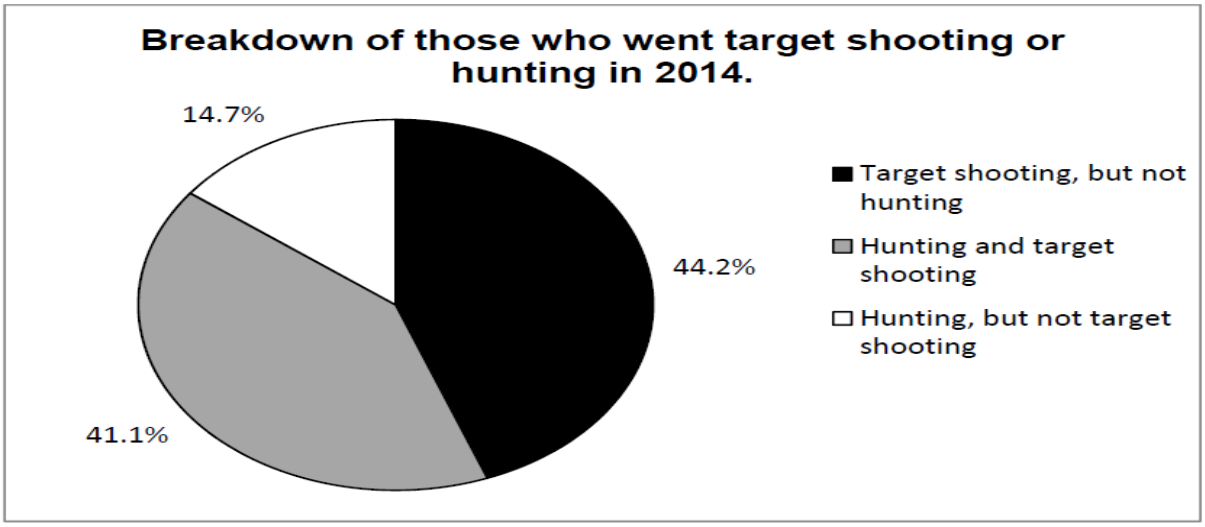
US data indicate that there are approximately 20 million target shooters in the US. Each US shooter spent an average of $493 USD per year on their sport with $406 USD spent on equipment of which $58 USD was on ammunition[91.] Compared to hunters, target shooters spend less on travel and more on equipment due to the relative proximity of most shooting ranges – the average target shooter in the US spent $87 USD on trip-related expenditures.[92] In general, hunters spend more than target shooters – most of the differences lie in travel and accessories since hunters travel greater distances to find places to hunt. In addition, hunters buy big-ticket items rarely purchased by target shooters e.g. campers, pick-ups and other vehicles.[93] However, it can be hard to distinguish expenditures between the groups as many target shooters are hunters and vice versa. As an example, the same rifle used for hunting can be used for target shooting.

[89] Southwick Associates 2013. Target Shooting in America. Produced for the National Shooting Sports Foundation (NSSF)
[90] Ibid
[91] Ibid
[92] Ibid
[93] Ibid

Available data on hunter expenditures in Canada varies between provinces. In Ontario, Canadian hunters spent about $1.2 billion a year on hunting trips and paid $70 million for hunting licenses. It has been estimated that the hunting industry in Quebec generates economic benefits exceeding $300 million. Hunters in Alberta spent more than $102.5 million in direct hunting expenditure, and BC hunters spent $116 million. Manitoba hunters and anglers expenditures generated $312.2 million (hunting and angling not separated) and 8% of these expenditures went to lodges and outfitters. In Saskatchewan, hunters spent $108 million, with $39 million of this being outfitted hunting.[94] The most recent national data on hunter expenditures are of limited value and it is very dated as it is from 1996. In this previous study, on average, hunters in Canada spent an average of $692 per year in hunting expenditures with hunting equipment accounting for ~47% of the expenditures, ~20% for transportation, ~17% for food and accommodation, and ~17% for licence fees and ammunition (ammunition costs were not separated out). In 1996, large game hunters spent the highest average annual amount on their hunting at $587, followed by waterfowl hunters ($384), small game hunters ($297) and hunters of birds other than waterfowl ($288).[95] A more recent study on hunter expenditures in BC indicated that average annual expenditures per hunter in 2012 were $2,900 per year and 3.4% of these expenditures were due to ammunition.[96] Most hunter expenditures (24%) were due to large items (e.g. trucks, ATVs, trailers, cabins), ~21% was due to vehicle fuel, ~20% firearms, camping and hunting equipment, ~15% food and beverages, ~4% licences, and ~2% for lodging.[97] This was similar to the situation in the US where annual expenditures were ~$2,500 per hunter in 2011 and 3.9% of this was due to ammunition purchases.[98]

The overlap between hunters and sport shooters was examined in a recent NSSF report which found that about 2 in 5 of those who either hunted or went target/sport shooting did both activities (see Figure 16 below).

Figure 16. Overlap in participation in Target Shooting and Hunting (NSSF, 2015)

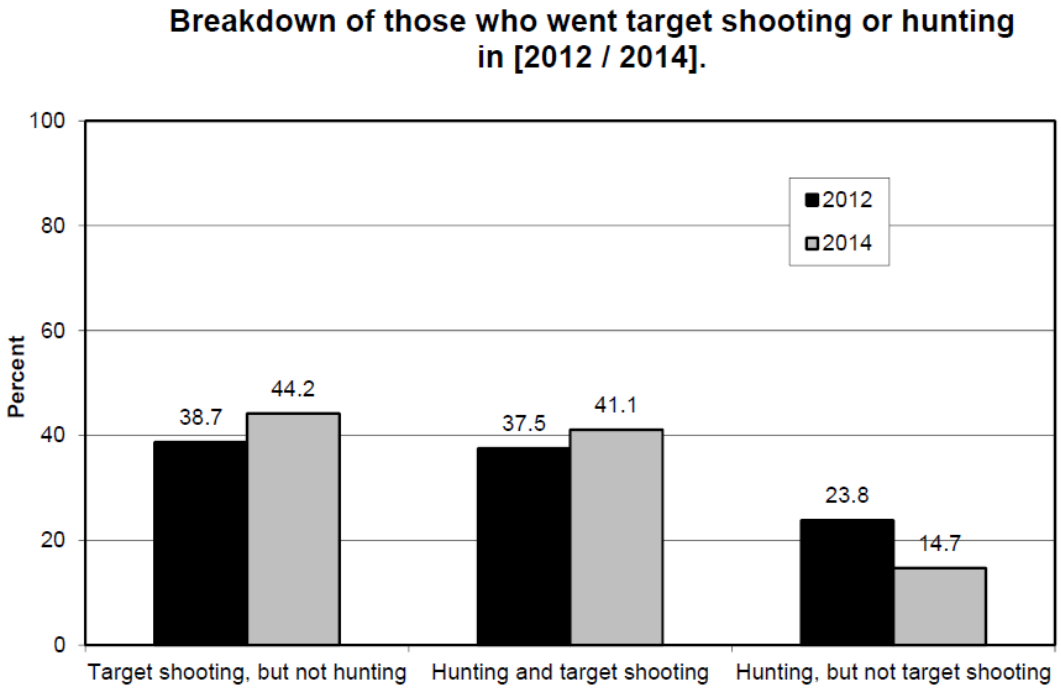


Source: NSSF Report (2015): Sport shooting participation in the United States in 2014. Prepared by Responsive Management. http://www.armalot.com/wp-content/uploads/2016/08/NSSF-Sport-Shooting-Participation-Report-1.pdf

The NSSF (2015) study also found that hunting, exclusive of target/sport shooting, declined from 2012 to 2014 (see Figure 17).

[94] Sport Fishing and Game Hunting in Canada. Canadian Tourism Commission, Research and Evaluation; Oct 2012.
[95] Hunting for Tomorrow: http://www.huntingfortomorrow.com/HFTF_Home/Issues_files/Canadians%20Hunt%20Wildlife.pdf
[96] Expenditures of British Columbia Resident Hunters (2012): http://www.env.gov.bc.ca/fw/wildlife/docs/bc_expenditures_rpt_comparison.pdf
[97] Ibid
[98] Ibid, see Table 2 in Expenditures of British Columbia Resident Hunters (2012)

Figure 17. Hunting and Sport Shooting Participation Overlap 2012-2014 (NSSF, 2015)



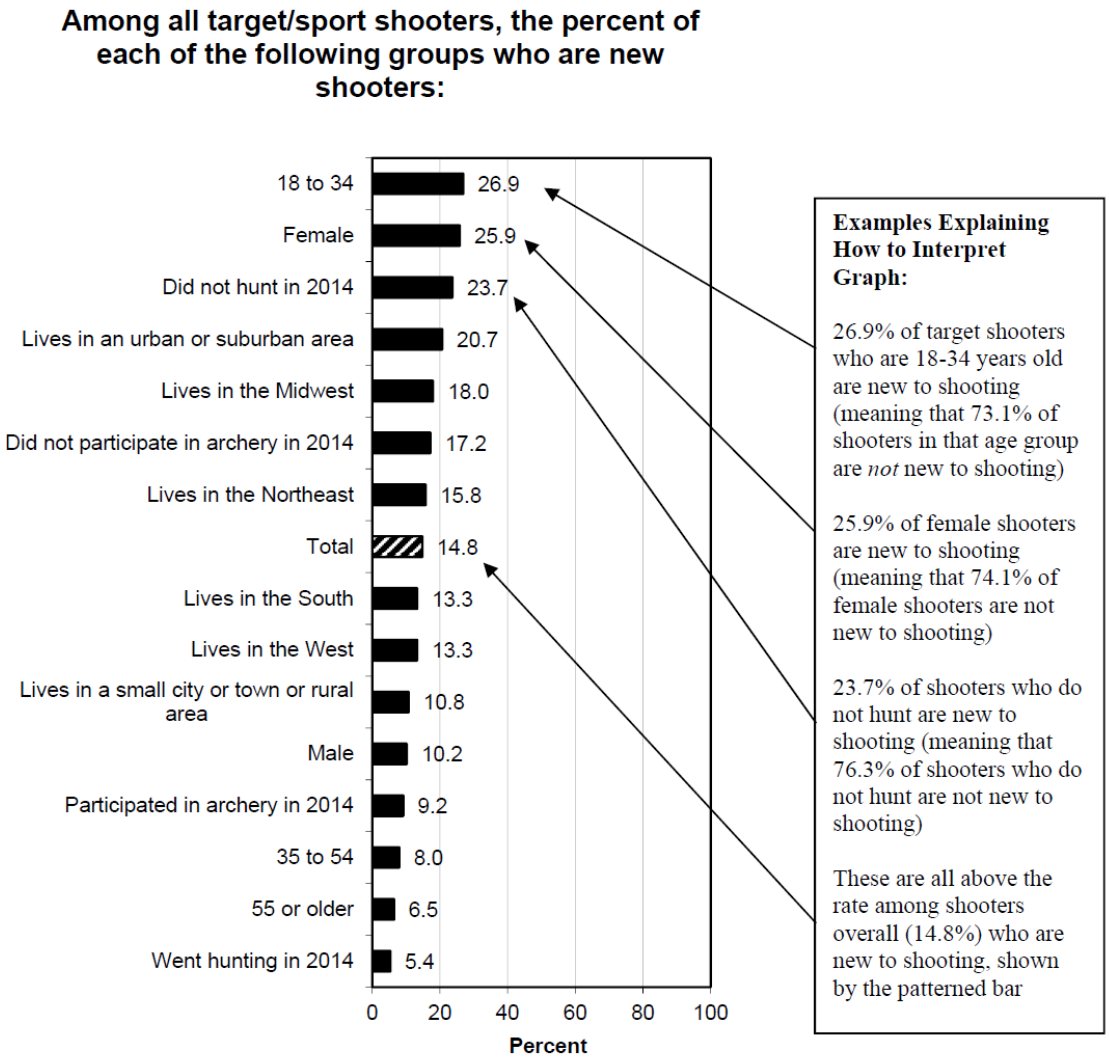
Source: NSSF Report (2015): Sport shooting participation in the United States in 2014. Prepared by Responsive Management. http://www.armalot.com/wp-content/uploads/2016/08/NSSF-Sport-Shooting-Participation-Report-1.pdf

The NSSF (2015) report also provides a profile of the typical sport shooter – participation is correlated with being male, being aged 18-34 years old, hunting participation, and living in a small town or more rural area. The NSSF (2015) study also surveyed participants on their motivations for sport shooting. Social reasons top the list with 68% of respondents saying 'being with family and friends' was a very important reason for their participation, with 61% citing 'sport and recreation', 59% self-defence, 53% saying 'to practice or prepare for hunting', 44% to 'mentor a new shooter' and 13% to practice for their job.

Increased participation in the shooting sports has been observed in recent years. NSSF (2015) noted an increase participation in the US from 34.4 million people in 2009 to 51.2 million in 2014 (an average annual increase of approximately 3.4%). New shooters tended to be in the younger demographic (18-34 year old), to be female, not hunters, and to be on the urban end of the urban-rural continuum (see Figure 18 below).[99]

[99] Sport Shooting participation in the United States in 2014. Prepared for the National Sport Shooting Foundation (NSSF) by Responsive Management. http://www.armalot.com/wp-content/uploads/2016/08/NSSF-Sport-Shooting-Participation-Report-1.pdf

Figure 18. Profile of New Shooters (NSSF, 2015)



Source: NSSF Report (2015): Sport shooting participation in the United States in 2014. Prepared by Responsive Management. http://www.armalot.com/wp-content/uploads/2016/08/NSSF-Sport-Shooting-Participation-Report-1.pdf

Increasing sales associated with increased participation in the shooting sports has been noted by US ammunition manufacturers for example:

Remington noted in their Annual Reports for 2014 and 2015[100] that "The aggregate commercial firearms, ammunition and accessories markets in the United States were approximately $14 billion in 2013. As a result of favorable industry-wide trends, including broader participation in hunting and shooting sports, an increasing number of female shooters, an increased focus on home and self-defence and recent rises in demand brought about by regulatory and legislative concerns, our markets have expanded over the past five years....According to the National Shooting Sports Foundation (NSSF) domestic consumer ammunition sales grew at a 16.4% CAGR from 2009 to 2013…. According to the NSSF, for the period between 2008 and 2012, 66% of new

[100] Remington Outdoor Company Inc. Annual Report March 2014: http://www.freedom-group.com/2013%2010-K.pdf and 2015: http://www.freedom-group.com/ROC%202015%2010-K%20Annual%20Report.pdf

shooters were between the ages of 18 and 34 and 37% of new target shooters were female, demonstrating the industry's favorable and sustainable demographic growth trends. We believe that as new participants are introduced to the market, it will lead to consumers purchasing multiple firearm and ammunition products as their participation in shooting sports broadens." also stated is… "As the popularity of hunting, shooting and outdoor sports increases, retailers serving this market continue to expand their locations and product offerings to capitalize on these trends. For example, retailers such as Cabela's, Wal-Mart, Bass Pro Shops etc. continue to expand the number of their locations that stock our products. Unlike many of our competitors that sell their products exclusively to distributors, approximately 45% of our commercial net sales in 2014 were directly to major retail and sporting goods chains, such as Cabela's, Wal-Mart, Bass Pro Shops."

Similarly Vista Outdoor noted increasing sales in recent years: "Shooting Sports generated 62% of our external sales in the nine months ended January 3, 2016. The Shooting Sports product lines include centerfire ammunition, rimfire ammunition, shotgun cartridge ammunition, reloading components, centerfire rifles, rimfire rifles, shotguns and range systems. Vista Outdoor sales due to shooting sports increase by 15.4% between 2014 and 2016.[101]

3.3 Alternatives to Lead Ammunition: Advantages and Disadvantages

3.3.1 Hunting Ammunition

A recent study on the alternatives to lead ammunition for hunting concluded that there was wide product availability of cost effective, high quality, lead free ammunition in the USA and Europe ensuring that it was possible to phase out the use of lead hunting ammunition worldwide based on progressive policy and enforceable legislation.[102]

3.3.1.1 Performance and Availability

3.3.1.1.1 Centrefire, Rimfire

The Institute of Wildlife Studies (IWS)[103] states that non-lead bullets are extremely effective and notes that bullets made from 100% copper were initially developed by Barnes Bullets in the mid 1980's as a premium bullet for big-game hunting in Africa. They were found to have excellent performance properties including extremely consistent and rapid expansion, combined with excellent weight retention and associated deep penetration. In addition, they gained a reputation as being very accurate. Continued advancements have resulted in more manufacturers producing numerous calibres and bullet weights using either 100% copper or gilding metal construction (typically 90% copper). Non-lead bullets are now available in factory loaded ammunition from all major manufacturers[104] including Federal, Hornady, Winchester, and Remington, as well as for reloaders.

One of the advantages of these types of non-lead bullets is that they do not fragment like lead bullets (see Figures 19-21 below)

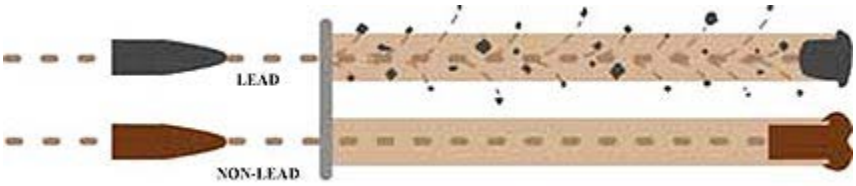
[101] Vista Outdoor SEC Filings: http://investors.vistaoutdoor.com/Docs/

[102] Thomas (2013) Lead-free hunting rifle ammunition: Product availability, price, effectiveness, and role in global wildlife conservation. AMBIO 2013, 42: 737-745

[103] The US-based Institute of Wildlife Studies (IWS) is a non-profit group of hunters and wildlife biologists that is dedicated to promoting hunting and wildlife conservation through the use of non-lead ammunition.[103] This group provides extensive information on the advantages and disadvantages of lead and non-lead hunting ammunition.

[104] E.g. see list of approved non-lead hunting ammunition approved for hunting in California in Appendix 3

Figure 19. Bullet Fragmentation: Lead vs 100% copper or gilding metal construction (typically 90% copper)



Source: IWS (2015)

Fragmentation in modern centrefire lead rifle bullets is a direct result of their design to be a controlled-expansion projectile. They are specifically designed so that the frontal portion of the bullet consistently and reliably expands to almost twice their original diameter.

This design does a couple of things to ensure a quick and humane kill:

1. It delivers a hydrostatic shock wave that travels out from the bullet's path and into the animal's body that has received the bullet, causing significant damage to internal organs and bones.
2. It ensures that when the bullet passes through the body, the increased diameter and sharp edges of the expanded bullet causes more internal physical damage to the animal.

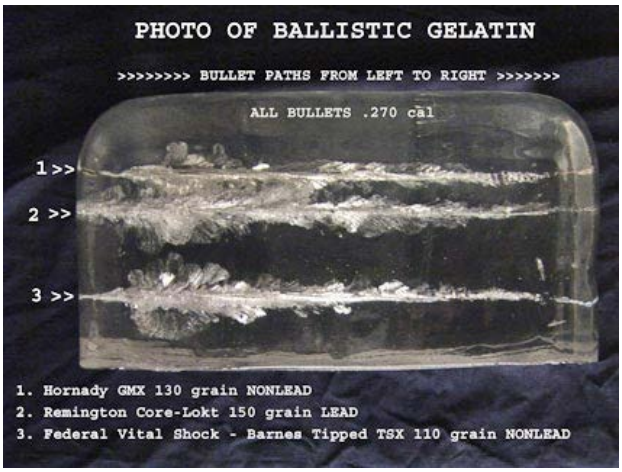
However, one other consequence of a rapidly expanding lead bullet traveling at high velocities is that some of the soft metal itself erodes away from the frontal section of the bullet as it strikes and travels through the animal. The fragmenting characteristic of lead bullets is cause for concern for wildlife and humans who eat any portion of an animal shot with this type of bullet. While efforts have been made to retain the expanding characteristic of lead bullets, but eliminate the fragmenting aspect (e.g. special bonding of the jacket to the bullet core), none have been entirely successful in this regard.[105] IWS also notes that lead rim fire ammunition (e.g. .22 calibre bullets) which can be used to hunt smaller game animals, also fragment extensively despite travelling at lower velocities. Hunt *et al*., 2009, X-rayed rifled-killed deer hunted with lead bullets and found all contained lead fragments, with 74% containing >100 lead fragments. These lead fragments were then shown to be bioavailable and could result in elevated blood lead levels following ingestion.[106]

IWS has shown that non-lead bullets compare very favourably with lead bullets in terms of ballistics (see Figure 20). In this test two popular non-lead bullets (100% copper and copper-zinc alloy containing 90% copper) and one lead bullet used for hunting were fired into the same block of standard ballistic gelatin to compare expansion, penetration, and hydrostatic shock. The two non-lead (copper) bullets compared very favourably to the lead bullet in terms of performance.

[105] IWS 2015: www.huntingwithnonlead.org

[106] Hunt WG, Watson RT, Oaks JL, Parish CN, Burnham KK, Tucker RL, et al. (2009) Lead Bullet Fragments in Venison from Rifle-Killed Deer: Potential for Human Dietary Exposure. PLoS ONE 4(4): e5330. doi:10.1371/journal.pone.0005330

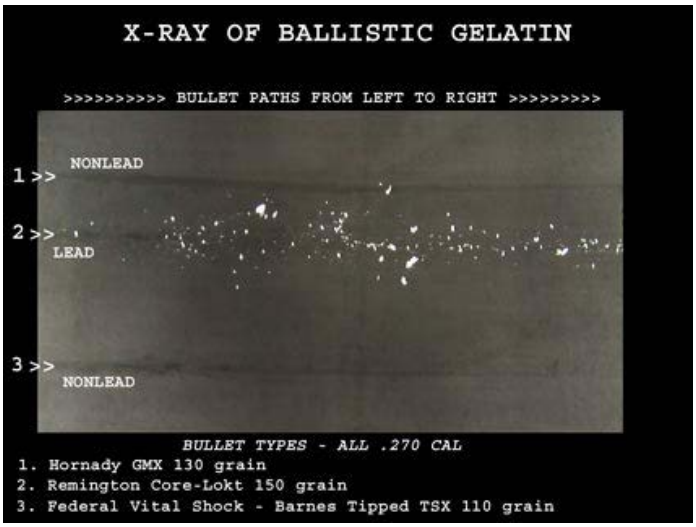
Figure 20. Non-Lead Hunting Bullets (100% Copper and 90% Copper) Comparable Ballistic Properties/Performance with Lead



Source: Institute of Wildlife Studies: http://huntingwithnonlead.org/whyUseNonlead2015.html. Hornady GMX bullet is made of gilding metal, which is copper-zinc alloy (brass) that is 90% copper (#1); Remington Core-Lokt bullet is a lead core copper jacketed bullet containing 90% lead (#2); Barnes TSX bullet is 100% copper (#3)[107]

The following Figure 21 is an x-ray of the same gel block showing substantial fragmentation of the lead-core bullet (30% of the bullets initial weight is left in fragments in the block). In contrast the non-lead bullets show virtually 100% weight retention resulting in greater penetration, which would result in greater tissue damage as the bullet does not break apart and continues to do damage to the animal all the way through to the exit wound. The fully expanded non-lead bullets leave the exit wound approximately twice the diameter as the entry wound, resulting in greater blood loss and hence faster kills whilst also allowing effective tracking.

Figure 21. Non-Lead Hunting Bullets (100% Copper and 90% Copper) Comparable Ballistic Properties/Performance with Lead (X-Ray)



Source: Institute of Wildlife Studies: http://huntingwithnonlead.org/whyUseNonlead2015.html.

[107] See also 'Copper bullet study' from Dept. Natural Resources Wisconsin: http://soarraptors.org/wp-content/uploads/CopperBulletStudy_small.pdf

In addition, Prof. Thomas summarized the performance data on lead-free hunting bullets and concluded the following:

'The effectiveness and lethality of lead-free rifle bullets made of copper or gilding metal have been demonstrated by field shooting on UK species of deer (Knott et al. 2009) and on German species of deer and wild boar (Sus scrofa) by Spicher (2008). These results have been supported by the experimental shooting of euthanised sheep and wild white-tailed deer Odocoileus virginianus by Grund et al. (2010) at distances of 80-175 m. Further evidence of the effectiveness of lead-free rifle bullets is provided by detailed, controlled, ballistic experiments of Trinogga et al. (2013) and Gremse et al. (2014). Both studies concluded that lead-free bullets were equally as effective as lead-core counterparts in expanding, creating destructive wound channels, and retaining their initial mass after penetration. It is possible that some tiny copper bullet fragments could be ingested by scavengers (e.g. golden eagles Aquila chrysaetos) and humans. However, Franson et al. (2013) reported that American kestrels Falco sparverius experimentally-dosed with copper pellets did not exhibit any signs of toxicity.' [extract from Thomas, 2015[108]]

In addition, a recent study by Kanstrup *et al*. (2016)[109] found that lead-free and lead-core rifle bullets were equally effective in producing rapid, one shot, kills of red deer and roe deer in Europe.

Technical Considerations in Switching to Non-lead

Non-lead monolithic bullets (e.g. 100% copper hunting bullets) are longer than lead core bullets of the same weight. Longer bullets may react differently, depending on the twist rate the gun barrel. It is recommended to choose a lighter non-lead option to result in a similar length and performance to the lead bullets that the hunter is familiar with.

Thomas *et al*. (2016)[110] examined concerns of hunters regarding non-lead bullets and their perceptions of availability, costs, efficacy, accuracy, toxicity, and barrel fouling. Thomas *et al.* (2016) concluded product availability of non-lead rifle ammunition in a wide range of calibres is large and is suited for all hunting situations. It was noted that at least 13 major ammunition manufacturers make non-lead bullets for traditional, rare, and novel rifle calibres. Thomas *et al*. (2016) observed that local retail availability is now a function of consumer demand which relates, directly, to legal requirements for use. In addition, it was found that the costs of non-lead and equivalent lead-core hunting bullets are similar in Europe and pose no barrier to use. Thomas *et al*. (2016) found the efficacy of non-lead bullets equal to that of traditional lead-core bullets.

3.3.1.1.2 Shotgun pellets, slugs, muzzleloaders

Various types of non-toxic shot are available including shot based on steel (iron), tungsten, and bismuth.

Steel (iron): Steel ammunition is the most cost effective non-lead alternative to lead for shotgun ammunition for hunting. Steel is less dense than lead so ammunition manufacturers have solved this problem by increasing velocity, and/or increasing the shot weight in the cartridge. Increasing shot size when using steel shot for hunting offers equivalent or increased performance on game animals (IWS 2015). Studies have been shown that using steel shotgun loads is no different than using lead based loads in terms of killing effectiveness (IWS 2015). Nearly all shotgun ammunition manufacturers produce a steel shotgun cartridge.

Note that manufacturers/suppliers also provide technical information to end-users on the use of steel shot to achieve equivalent performance to lead shot e.g. by giving details such as steel vs lead load equivalence (see Table below). As shown in the following table, slightly more steel vs lead pellets can be used to achieve equivalent performance (see Table 39).

[108] Delahay, R.J. & Spray, C.J. (Eds.) (2015). Proceedings of the Oxford Lead Symposium. Lead Ammunition: understanding and minimising the risks to human and environmental health. Edward Grey Institute, The University of Oxford, UK. 152pp. To view online, see http://www.oxfordleadsymposium.info

[109] Kanstrup *et al*. 2016. Efficacy of non-lead rifle ammunition for hunting in Denmark. European J Wildlife Res 62(3): 333-340

[110] Thomas, V.G., Gremse, C. & Kanstrup, N. Non-lead rifle hunting ammunition: issues of availability and performance in Europe. Eur J Wildl Res (2016) 62: 633.

Table 39. Steel vs Lead Load Equivalence

	SIZE	*OZ.*	# OF PELLETS		*SIZE*	*OZ.*	# OF PELLETS
STEEL LEAD	BB BB	1 1 3/8	72 69	STEEL LEAD	BB BB	1 ¼ 1 7/8	90 94
STEEL LEAD	2 2	1 1 3/8	125 120	STEEL LEAD	2 2	1 ¼ 1 7/8	156 163
STEEL LEAD	4 4	1 1 3/8	192 186	STEEL LEAD	4 4	1 ¼ 1 7/8	240 253
STEEL LEAD	BB BB	1 1/8 1 5/8	81 81	STEEL LEAD	BB BB	1 3/8 2	99 100
STEEL LEAD	2 2	1 1/8 1 5/8	141 141	STEEL LEAD	2 2	1 3/8 2	172 174
STEEL LEAD	4 4	1 1/8 1 5/8	216 219	STEEL LEAD	4 4	1 3/8 2	264 270

Source: Challenger Ammunition (QC): http://www.munitionschallenger.com/english/steel_eng.html

Tungsten: Tungsten or tungsten based alloys are denser than lead. Tungsten is often more expensive than lead-based ammunition. Tungsten is considered a highly effective alternative to hunters using buckshot (e.g. turkey, predator, pig hunters). These game animals often offer limited shooting opportunities when compared to the high volume of ammunition a hunter goes through while waterfowl and upland game hunting (IWS, 2015) – hence the cost of each cartridge is less of a concern as so few cartridges are used per year. Manufacturers include Kent Cartridge, Hevi-shot, Federal, Remington and Winchester.

Bismuth: Bismuth is a good alternative for hunters using vintage shotguns that may not tolerate the higher velocity or hardness of steel and tungsten ammunition provides. Bismuth is 86% as dense as lead, giving it excellent down range energy and similar ballistic characteristics. It is also the choice for hunters wanting similar characteristics of lead without paying for the price of tungsten based ammunition. Bismuth is the middle ground between steel and tungsten ammunition. It is more expensive than steel however cheaper than most tungsten based shotgun loads. Rio and Kent Cartridge produce bismuth shotgun cartridges.

Shotgun slugs are designed for hunting big game. There are two different designs of shotgun slugs, saboted and rifled.

Saboted Slugs fit into a plastic cup that falls off once the bullet has left the muzzle of the rifle. Nearly all slugs are sabots and require a rifled shotgun barrel or rifled choke. Sabots can be tipped or un-tipped and are mostly hollow-points. The majority of non-lead slugs are made from copper or a copper alloy; however some are made with steel, brass, zinc or tin components. Most slugs open with 4 or 6 petals and retain most of their weight after being fired and provide high penetration and expand up to 2 times their original diameter. Examples include: Federal Trophy Copper, Remington Copper Solid , Winchester XP3, and Hornady Monoflex .

Rifled Slugs are shotgun slugs that already have grooves on the slug itself to promote rotation of the projectile to increase accuracy after it has left the muzzle. These slugs were designed to shoot out of smoothbore shotgun barrels, however they can also be used in fully rifled or barrels with rifled chokes. There are two different metals currently being offered in non-lead rifled slugs: food grade tin metal, and zinc. They have been reviewed by hunters as highly effective.[111] Manufacturers include Brenneke and Winchester.

[111] E.g. Review of tin shotgun slug: http://sportsmanslifestyle.com/deer-hunting-goes-green-brenneke-lead-free-shotgun-slug/

Round Ball muzzleloader non-lead bullets can either be purchased or cast at home. Some options are made of tungsten and are harder than lead. Home cast versions can be made with standard casting equipment using a mixture of 93% Bismuth, 7% Tin. These have similar hardness to a high-antimony lead ball, but are slightly lighter.

Technical Considerations in Switching to Non-lead

Virtually all shotguns can shoot non-lead shotgun cartridges (IWS, 2015). The only exception are shotguns that have Damascus steel twist barrels and barrels with fixed full or tighter chokes. However, shotguns with Damascus barrels are usually >100 years old and not used commonly for game shooting. In these cases, bismuth is an alternative to lead when using vintage shotguns or shotguns that have fixed full chokes.[112] Since steel and tungsten are harder than lead they could cause a small "ring bulge" in the choke region of full and extra-full choked barrels. This is of concern when using shot of size larger than US #4. Smaller diameter (shot sizes smaller than #4 US) steel and other hard non-lead shot can be fired safely through full chokes without danger of causing ring bulges. Such ring bulges are cosmetic: they do not impact adversely the safety of the gun barrel.[113]

Chokes used for non-lead cartridge shooting are different than ones designed for lead only. Generally, when using non-lead shot a choke with one degree less constriction than a lead-only choke is used. Since steel and tungsten are harder than lead they are not able to pass through as tight of choke constrictions. For example, for a full choke lead shot pattern one would use a modified choke when shooting steel or tungsten alloy. For a typical modified lead shot pattern using a non-lead load one would use an improved cylinder. Bismuth and tungsten matrix shot have very similar characteristics to lead shot and no further action is needed when choosing choke constrictions (IWS, 2015)

3.3.2 Sport Shooting

Ammunition manufacturers make non-toxic alternatives for sport shooting including shot based on steel (iron), tungsten and bismuth. The alternatives that can be used for hunting and discussed in Section 3.3.1 can also be used in shooting sports.

3.3.2.1 Shotgun Sports

Shotgun sports include Trap and Skeet, and Sporting Clays. Ammunition manufacturers make non-toxic shot alternatives for shotgun sports made primarily out of steel, bismuth, and tungsten. Steel is the most cost-effective alternative currently available for the shotgun sports: bismuth and tungsten-based cartridges are too expensive to be used extensively.

Opponents state that the shot loads with alternative materials are more expensive than lead, less effective at breaking the clay targets, and potentially damaging to the gun e.g. because some of the metals used (e.g. steel) are harder than lead.[114] However, experts have found that steel pellets are as effective as lead in breaking clay targets, and the shot does not damage modern guns, in part because plastic or biodegradable material

[112] Choke refers to the inside bore constriction at the muzzle end of the shotgun barrel. The choke controls the spread of shot – making it narrower or wider (similar to the action of a nozzle at the end of a garden hose controlling the spray of water). The three basic chokes for a shotgun are known as "full" (tight constriction; delivers a narrow, dense spread), "modified" (less constriction; delivers a medium-width spread) and "improved cylinder" (even less constriction; delivers a wide, open spread). A gun which has no choke is called a "cylinder bore" and delivers the widest spread. There are also a number of specialty chokes that provide narrower or wider spreads--some of the most popular are for skeet shooting and turkey hunting. A shotgun's choke also determines its effective range. The tighter the constriction the farther the effective range. Shotgun barrels come with either "fixed' (non-removable) chokes or today's more popular "interchangeable" screw in choke tubes that allow the choke to be changed.

[113] Prof. V.G. Thomas pers. comm. March 2017.

[114] E.g. see http://www.sporttechie.com/2016/08/07/green/should-olympic-sport-shooting-events-stop-using-lead-shot/

encapsulates the shot and protects the gun's barrel.[115] Manufacturers have designed shotgun cartridges to take into account the fact that steel is harder than lead (e.g. Remington's guide to shotguns and shotgun ammunition states 'because steel is harder than lead, the shot cups used for steel shot are designed from higher density polyethylene with thicker sidewalls to prevent the pellets from scoring the bore'). In addition, Remington notes that steel shot has a higher initial velocity than lead when it first exits the muzzle but, due to its lighter weight, it can lose knock down power at longer distances. To counteract this it is recommended to use larger steel shot sizes to maintain comparable velocity and retained energy of that of lead, even at long distances. Remington recommends using steel shot sizes that are two sizes larger than those used for lead. Since steel is less dense than lead, the larger shot size allows the shooter to have the same 'weight charge' load with roughly an equivalent number of pellets – therefore maintaining comparable pattern performance and pellet energy to lead loads.[116] Hence, the differences between lead and steel shot are easily compensated for in cartridge design and by adjusting the size of shot used. Most clay targets in skeet, trap, and sporting clays shooting are broken well within the effective range of shotgun ammunition (approx. 40m).[117]

Price comparisons of shotgun cartridges containing steel and lead shot in Canada indicate that steel is more expensive, although the difference is small. It would be expected that increased demand would lead to economies of scale and reduce costs with greater adoption of steel. Other alternatives, such as tungsten and bismuth, are currently significantly more expensive than lead. Retail price comparisons by Thomas (2015) indicated that there should be no economic impediment to shooters adopting steel shot cartridges. The retail prices of alternatives were found to reflect world prices for the component metals, based on their rarity, strategic importance, costs of processing and assembly into shot. Thomas (2015) concluded that an increase in the economy of scale might lower the absolute costs of tungsten-based and bismuth-based shot, although not much change in the relative prices as a function of demand was expected.[118]

Some shooting ranges stated that they do not allow steel to be used in trap and skeet, or to shoot metal targets, as they believe that steel increases the possibility of ricochets. However, it should be noted that ricochets can happen with any firearm and any bullet type and are most likely to occur with long velocity bullets including lead bullets.[119] Several reports have noted that potential ricochet concerns associated with steel are exaggerated.[120] Note that ranges that continue to have this specific concern have the option to encourage the use of other alternatives, such as bismuth, which has a similar softness to lead, although it is more expensive. Range design and practices could also be adapted to reduce hard surfaces in the shot zone, thereby reducing the probability of ricochets for all ammunition types.

Steel, bismuth and tungsten shot have been found to perform well for both shooting sports with clays, and for hunting.[121]

3.3.3 Toxicity

The use of lead rifle ammunition in hunting has disadvantages associated with the toxicity of lead which are not associated with the copper alternatives. Copper or copper-zinc alloy (gilding metal) bullets or bullet remnants are not expected to pose toxic risks to scavengers, predators or the wider environment (Thomas, 2013; Thomas 2015).

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[115] Tom Roster, an independent shotgun ballistics expert in Oregon, and Prof. Vernon Thomas, e.g. see http://www.sporttechie.com/2016/08/07/green/should-olympic-sport-shooting-events-stop-using-lead-shot/

[116] Remington Guide to Shotguns and Shot Cartridge Ammunition (2016): https://support.remington.com/General_Information/Guide_to_Shotguns_and_Shotcartridge_Ammunition

[117] Prof. V. Thomas pers. comm. March 2017.

[118] Thomas (2015). Availability and use of lead-free shotgun and rifle cartridges in the UK, with reference to regulations in other jurisdictions. Proc. Oxf. Symp. Lead Ammunition: understaning and minimising the risks to human and environmental health p85-97

[119] E.g. see Range Dangers: http://blog.cheaperthandirt.com/range-dangers/

[120] AMEC 2012. Report on Lead Shot used for Hunting in the EU. AMEC Environment and Infrastructure, Dec 2012 prepared for the European Chemicals Agency (ECHA)

[121] Armbrust, T. (2008) Non-toxic Update: Bismuth Shot: http://www.armbrust.acf2.org/nontoxicupdate1and2.htm; Armbrust, T. (2008) Kent Impact Tungsten Matrix: http://www.armbrust.acf2.org/tungmatrix.htm ; Armbrust, T (2008) Steel Shot Target Loads http://www.armbrust.acf2.org/steelshot.htm

The non-lead shot alternatives, based on steel, tungsten or bismuth, have all been approved by the US Fish and Wildlife Service and the Canadian Wildlife Service as non-toxic alternatives to lead. Non-toxic shot is defined as any shot type that does not cause sickness and death when ingested by migratory birds.[122]

While all metals when ingested in excessive quantities can cause toxic effects, it should be noted that all the alternatives exhibit non-toxicity compared to lead.[123] In particular, the most commonly used and cost-effective lead-free alternatives are copper bullets and steel shot for which there is extensive information supporting their use as non-toxic replacements for lead.

3.3.2.2 Human Health Concerns

3.3.2.2.1 Exposure and toxicity associated with hunting ammunition

Fragmentation of lead bullets in game meat is a public health concern as fragments from lead rifle ammunition can peel off and become lodged in tissue as much as 14 inches from the point of bullet entry (see Figure 22).[124]

Figure 22. X-Ray mule deer carcass showing lead fragments well beyond bullet trajectory

Source: Minnesota Department of Natural Resources; IWS, 2015

There is increasing awareness that consuming game meat can result in elevated blood lead levels due to lead contamination of the meat from ammunition fragments.[125] Recent studies in Quebec indicated that lead exposure through game meat consumption, where the animal has been killed with lead ammunition, is a

[122] US FWS, Nontoxic shot regulations for hunting waterfowl and coots in the US.: https://www.fws.gov/birds/bird-enthusiasts/hunting/nontoxic.php

[123] For example, in a 150-day study ducks dosed with 8 lead shot pellets all died whilst those dosed with 8 steel (iron) or tungsten shot pellets all survived and showed no adverse health impacts: https://www.ncbi.nlm.nih.gov/pubmed/11504218 ; A 32-day study following ingestion of 12-17 pellets of tungsten-bismuth-tin shot by ducks also indicated no adverse health impacts: https://www.jstor.org/stable/3809072?seq=1#page_scan_tab_contents

[124] IWS 2015: http://huntingwithnonlead.org/whyUseNonlead2015.html

[125] For example, see Couture *et al.,* 2012. Lead exposure in Nunavik. Intl J Circumpolar Health 71: 18591 - http://dx.doi.org/10.3402/ijch.v71i0.18591; Levesque et al., 2016 Monitoring of umbilical cord blood lead levels and sources assessment among the inuit. Occup Environ Med 2003: 60: 693-695; Verbrugge *et al*., 2009 Human exposure through ammunition in the circumpolar north; Lindboe *et al*., 2012 Lead concentration in meat from from lead-killed moose and predicted human exposure. Food Addit. Contam. 1-6; Hung *et al*., 2009 Lead bullet fragments in venison from rifle-killed deer: Potential for human dietry exposure. PLoS ONE 4(4): e5330

significant concern for susceptible subpopulations (e.g. children and pregnant women), particularly those relying heavily on game meat (Fachehoun *et al*., 2015).[126] These concerns are eliminated when copper rifle ammunition and lead-free shotgun ammunition is used for hunting.

3.3.2.2.2 Exposure and toxicity associated with shooting sports

Releases of lead occur during use of lead ammunition at shooting ranges and this can result in elevated airborne lead levels, particularly at indoor ranges. The potential lead exposure of recreational shooters was recently reviewed by Public Health Ontario (PHO), focusing specifically on indoor shooting ranges.[127] PHO conducted an exposure assessment at an indoor shooting range in Ontario and found that 4 out of 5 breathing zone samples performed on the shooters exceeded Ontario's occupational exposure limit of 50 µg/m^3 (8h time-weighted average (TWA)). Wipe and vacuum samples also showed the presence of lead in 8 of 9 surfaces tested. Lead dust at ranges can be easily transferred to hands, which can result in ingestion, and to clothes that can result in 'take-home lead' exposure of family members outside the range environment. Elevated blood lead levels in occupationally exposed workers at firing ranges are well documented e.g. the US Centers for Disease Control and Prevention (CDC) estimated that recreational target shooting was the likely source of lead exposure for 2,673 of 9,044 persons with elevated blood lead levels (BLLs).[128] Several studies have shown elevated BLLs in children and young adults who practice shooting at indoor ranges. For example, Shannon (1999) found BLLs of 18-28 ug/dL[129] in adolescent girls who were competitive shooters even though health and safety measures (including hand washing and clothing changes) had reportedly been followed.[130] A study in Alaska found elevated BLLs among students (aged 7-19 years; mean BLLs ranged from 7.6 ug/dL to 24.3 ug/dL) on shooting teams at 4 out of 5 indoor ranges assessed.[131]

These concerns regarding lead exposure could be reduced by ensuring adequate ventilation and house-keeping practices at indoor ranges. The concerns could be eliminated if non-toxic ammunition were used in place of lead ammunition.

3.3.2.3 Wildlife Toxicity

3.3.2.3.1 Exposure and toxicity associated with lead hunting ammunition

Birds and mammals feed on the gutpiles and carcasses that they find during and after hunting season and consequently ingest lead when the carcasses have been shot with lead ammunition. Evidence that wildlife mortality occurs when lead fragments remain in gutpiles or carcasses is extensive and includes studies on bald eagles, Stellar's sea eagles, condors, and ravens amongst others.[132] [133] [134]

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[126] Fachehoun *et al*., 2015. Lead exposure through consumption of big game meat in Quebec, Canada: risk assessment and perception. Food Additives & Contaminants: Part A. 32:9, 1501-1511

[127] Ontario Agency for Health Protection and Promotion (Public Health Ontario) 2014: Lead exposures among recreational shooters, Toronto ON 2014 ISBN: 978-1-4606-4737-0.

[128] Beaucham et al., 2014. Indoor firing ranges and elevated blood lead levels – United States, 2002-2012. MMWR Morb Mortal Wkly Rep 2014; 25;63(16): 347-51 (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6316a3.htm)

[129] A BLL of10 ug/dL is the level at which public health action is recommended. It is increasingly recognized that health impacts occur at levels much lower than this (including neurodevelopmental effects) and that no safe limit of exposure based on BLL can be established.

[130] Shannon 1999. Lead poisoning in adolescents who are competitive marksmen. N. Engl. J. Med. 1999; 9; 341(11): 852.

[131] Ramsey et al., 2013. Health hazard evaluation report: Followback evaluation of lead and noise exposures at an indoor firing range. http://www.cdc.gov/niosh/hhe/reports/pdfs/2012-0065-3195.pdf

[132] IWS 2015: http://huntingwithnonlead.org/whyUseNonlead2015.html; Weiss, 2014. National Geographic: Many bald eagles are victims of lead poisoning: http://news.nationalgeographic.com/news/2014/08/140829-poison-eagle-lead-bullet-rescue-wildlife-science-winged-warning/

[133] Reviewed in: Arnemo et al., 2016. Health and Environmental Risks from Lead-based Ammunition: Science versus socio-politics. EcoHealth. DOI:10.1007/s10393-016-1177 published online Sept 23 2016

[134] Recent Canadian examples: Hunters urged to switch to copper ammo after bald eagle dies of lead poisoning http://www.cbc.ca/news/canada/nova-scotia/hunters-copper-ammo-cape-breaton-eagle-lead-poisoning-1.3914901

The history of poisoning of wild birds through the ingestion of spent lead shot is extensive and has been summarized by Pain *et al.* (2015). A recent study from Canada by Legagneux *et al.* (2014) found that blood lead concentrations in the raven, a scavenging species, increased over the moose hunting season in eastern Quebec, Canada, and that the birds with elevated blood lead levels had isotopic signatures that tended towards those of ammunition.[135] The fact that continued mortality of wildlife due to lead shot ingestion remains a concern is illustrated by Pain *et al* (2015) who estimated that 73,750 birds die each year in the UK due to lead poisoning associated with ingestion of lead ammunition. These concerns are eliminated when copper ammunition is used for hunting.

3.3.2.3.2 Exposure and toxicity associated with lead ammunition used in shooting sports

Outdoor shooting ranges have extremely high metallic lead burdens in soil (Darling and Thomas, 2005).[136] Previous studies have concluded that the species most likely to be at risk through direct ingestion of spent lead or contaminated soil on or near shooting ranges are species that forage on the ground or use grit to help aid in digestion.[137] Lead exposure and poisoning have been documented in birds that forage in areas contaminated with lead from shooting ranges (Roscoe *et al.* 1989;.[138] Vyas *et al.* 2000).[139] Reid and Watson (2005) found soil levels of 6,410 +/- 2,250 and 296 +/- 98 mg(Pb)/kg dw, respectively at a clay-pigeon shooting site soil and a control site and body burdens of earthworms were almost 1,000 times higher than those from the control site.[140] Rodriguez-Seijo *et al* (2016 and 2017) found high concentrations of lead in the soil at an abandoned shooting range in Spain which exceeded limit values for urban soils and were associated with lead bioaccumulation in earthworms[141]. Other studies have shown that small mammals sampled within the impact zone of a shooting range show signs of lead toxicosis (Stansley and Roscoe 1996)[142]. Stansley *et al.* (1997) found high mortality in eggs of frogs exposed to lead contaminated surface water from a trap and skeet range. In this study, the lead concentration in the shooting range run-off water was found to be 3,150 µg Pb/l, and 100% mortality was observed after 10 days of exposure.[143] Further details on lead releases and resultant toxicity associated with lead ammunition uses at shooting ranges are provided in section 4.1 of this report.

3.3.3 Cost

All non-lead alternatives are more expensive than traditional lead ammunition – an illustrative comparison of current costs for equivalent shotgun cartridges containing steel, tungsten and bismuth shot is provided in Table 40.

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[135] Legagneux *et al* (2014). High risk of lead contamination for scavengers in an area with high moose hunting success. PLoS ONE 9(11), e111546.

[136] Thomas and Darling (2005). Lead bioaccumulation in earthworms, *Lumbricus terrestris*, from exposure to lead compounds of differing solubilities. Sci. Tot. Environ. 346, 70-80

[137] Golden *et al* (2016). A review and assessment of spent lead ammunition and its exposure and effects to scavenging birds in the United States. In: Reviews of Environmental Contamination and Toxicology (P.de Voogt (ed)). Volume 237. 123-191

[138] Roscoe DE, Widjeskog L, Stansley W (1989) Lead poisoning of northern pintail ducks feeding in a tidal meadow contaminated with shot from a trap and skeet range. Bull Environ Contam Toxicol 42:226–233

[139] Vyas NB, Spann JW, Heinz GH, Beyer WN, Jaquette JA, Mengel-Koch JM (2000) Lead poisoning of passerines at a trap and skeet range. Environ Pollut 107:159–166

[140] Reid and Watson (2005)**.** Lead tolerance in (*Aporrectodea rosea*) earthworms from a clay pigeon shooting site. *Soil Biology and Biochemistry* 37(3), 609-612

[141] Spanish Generic Reference Level (GRL) of 100 mg/kg for lead

[142] Stansley and Roscoe (1996). The uptake and effects of lead in small mammals and frogs at a trap and skeet range. Archives of Environmental Contamination and Toxicology 30(2), 220-226.

[143] Stansley *et al.,* (1997). Effects of lead-contaminated surface water from a trap and skeet range on frog hatching and development. Environmental Pollution 96(1), 69-74

Table 40. Illustrative cost comparison for non-lead and lead shotgun cartridges (2017)

Shot gun cartridge type	Price per box (C$)	Number of cartridges per box	Cost per cartridge (C$)
Tungsten	36.99	10	3.70
Bismuth	20.99	10	2.10
Steel	21.99	25	0.88
Lead	12.99	25	0.52

Source: Prices were obtained on the same day in Jan 2017 from Cabelas, cartridges compared were equivalent 12 gauge shotgun cartridges containing 1 1/4oz of shot.

Table 40 provides a worst case comparison for increased costs associated with non-lead shotgun ammunition as it compares the cheapest available lead option to the non-lead alternatives. A recent study on the costs of lead vs alternatives in the UK, a larger ammunition market than Canada, indicates that the cost of steel shot can be very similar to lead shot where greater economies of scale exist.[144]

Steel shot is the most commonly used alternative to lead for the legislated non-lead hunt and is the most cost-effective alternative currently available.

All major ammunition manufacturers supply copper hunting rifle ammunition. For example, Federal Premium introduced a line of affordably priced non-lead rifle ammunition in 2016 called "Power-Shok Copper'.[145] A box of 20 rounds of 150-grain 'Power Shok Copper' cartridges sells for C$45.50 which is a relatively small increase compared to a box of 20 rounds of 150-grain traditional lead-core rifle ammunition equivalent, which sells for $41.99 for 20 rounds. [146] For some hunters (e.g. deer hunters), a box of 20 rounds might last several years. A ~$4 increase over several years is considered insignificant, particularly when considered in relation to total annual expenditures associated with hunting.

Available data on hunter expenditures indicates that hunters spend on average $2,900 per year and that $98 of this is spent on ammunition.[147] Ammunition costs for hunters are therefore ~3.4% of total expenditures. These current expenditures are based on all types of hunting including non-lead ammunition used for the legislated non-lead hunt and lead ammunition used for hunting outside the legislated non-lead hunt. Using an average value per cartridge ~$1 per cartridge[148], and the total ammunition expenditures of $98 per year, it is estimated that ~98 cartridges are discharged on average annually per hunter.[149] Based on the relative costs of the alternatives in Table 40 above, and current uses of lead ammunition for hunting, it is estimated that the average cost increase per hunter per year associated with switching current uses of lead cartridges to non-lead

[144] Thomas (2015) Avaialability and use of lead-free shotgun and rifle cartridges in the UK, with reference to other jurisdictions. 85-97 In: Delahay & Spray (Eds) Proceedings of the Oxford Lead Symposium. Lead ammunition: understanding and minimising the risks to human and environmental health. The University of Oxford, UK 152pp.

[145] http://media.vistaoutdoor.com/news/press_release/press_release.aspx?id=724&brand=5&year=2016 price in USD of 33.95 converted to Canadian using an exchange rate of 1 USD: 1.34 CDN: http://www.x-rates.com/calculator/?from=USD&to=CAD&amount=1

[146] Price from Canadian Tire Feb 2017, Winchester Power Max 150 grain lead core centrefire ammunition recommended for deer and antelope: http://www.canadiantire.ca/en/pdp/winchester-300-mag-cal-150-grain-power-max-bonded-0751279p.html#srp

[147] Expenditures of British Columbia Resident Hunters (2012): http://www.env.gov.bc.ca/fw/wildlife/docs/bc_expenditures_rpt_comparison.pdf [Equivalent recent data for all of Canada was not found, most recent national data located was from 1996, and this did not provide specific data on ammunition expenditures]

[148] The average value of imported ammunition cartridges was ~$1 per cartridge, includes all cartridge types for which import data are available – hence can be used as a generic average cost per cartridge.

[149] The average number of cartridges discharged per year by hunters will vary widely between individual hunters with hunters of larger species such as deer using fewer rounds per year than hunters of smaller mammals, waterfowl, upland birds etc.

alternatives would be: $9 (for steel), $41 (for bismuth) or $82 (for tungsten).[150] Average annual expenditures on ammunition by hunters would be expected to remain at <7% of total expenditures even if the most expensive alternative (tungsten) is selected. Note that hunters that specialize in migratory bird hunting would experience no cost increase as they already hunt with non-lead ammunition. Hunters switching from lead ammunition to copper (e.g. deer hunters) would be expected to experience an increase of ~$4 per box of 20 rounds – if a full box is used in a year this increase would represent <1% of total annual hunter expenditures.

The sub-group that would be expected to be most impacted from a cost perspective would be sports shooters that use high quantities of ammunition per year, which is currently all low cost lead ammunition. The data from the electronic survey indicated that the quantity of ammunition used per sports shooter per year can vary from ~25 to thousands of rounds per year (Hunter Survey, 2017). As an illustrative case study we can use the average number of rounds per year reported for trap and skeet and sporting clays of 500-600 rounds per year (Hunter Survey, 2017), and convert these lead cartridges to steel ($0.52 cents per cartridge for lead to $0.88 per cartridge for steel; see Table 40). This indicates that individuals participating in these sports with higher average ammunition consumption patterns may experience an average cost increase of $180-$216 per year on switching to steel ammunition (based on current prices). Of the 512 respondents to the survey, ~20% reported participating in trap and skeet and ~34% reported participating in sporting clays; ~12% of respondents participated in both sports (Hunter Survey, 2017).

Some lobby groups argue that restrictions on lead ammunition will result in significant impacts on hunting participation due to the increase cost, with resultant negative economic consequences – the evidence does not support this argument.

3.3.4 Summary Comparison: Lead vs Alternatives

The following table briefly summarizes the comparison of lead ammunition vs non-lead alternatives in terms of performance/technical efficacy, availability, cost, and toxicity (environmental toxicity and human health impacts). The evaluation of the toxicity of alternatives is primarily based on the key concerns currently associated with lead ammunition, i.e:

- Toxicity to wildlife following ingestion (e.g. following ingestion of scattered shot, or bullet fragments in scavenged meat/gut piles)
- Toxicity to humans associated with consuming game meat containing shot/bullet fragments
- Toxicity to humans due to exposure to the substances via other routes associated with ammunition (e.g. inhalation of airborne substances in indoor ranges)

The main alternative for lead hunting bullets are 100% copper bullets or gilding metal (copper-zinc alloy which is 90% copper). Note that various alternatives for lead shot including steel, bismuth-tin, tungsten-iron, and tungsten polymer (tungsten-matrix) have been approved as non-toxic alternatives for use in the US and Canada in accordance with the Toxicity Test Guidelines of the Canadian Wildlife Service and by the US Fish and Wildlife Service (USFWS). These approvals are based on evaluations of the safety of the alternatives to confirm that they do not pose a significant toxic threat to migratory birds and other wildlife or their habitats. Steel, bismuth and tungsten are considered non-toxic to birds and are generally considered of non-toxic to humans.[151] Steel shot and copper bullets are the most commonly used alternatives currently available, and would be expected to be the main alternatives used to replace lead shot and lead bullets if increased use of non-toxic alternatives occurred.

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[150] This estimate is based on the fact that the legislated non-lead hunt is Canada is associated with ~7 million cartridges and reported harvest data for the lead hunt is associated with ~2 million cartridges – hence lead cartridges are expected to be 26 of the 98 total. The cost of replacement of these 26 lead cartridges per hunter with the steel, tungsten and bismuth alternatives is based on the cost per cartridge in Table 40.

[151] US Fish and Wildlife Service (USFWS) Migratory Bird Hunting: Approvals. Federal Register e.g. Fed. Reg. 71 (17) 4294-4297; Thomas et al., 2009. Assessment of the environmental toxicity and carcinogenicity of tungsten-based shot. Ecotox. Environ. Safety 72; 1031-1037; COWI 2004.Advantages and Drawbacks of restricting the marketing and use of lead in ammunition, fishing sinkers, and candle wicks. Report for the European Commission, Nov 2004.

Table 41. Summary Matrix comparing Non-Lead Alternatives to Lead Ammunition

Use	Ammunition type	Equivalent performance can be achieved with non-lead alternatives*	Availability**	Cost of alternatives vs lead	Toxicity of alternatives vs lead[152]
Hunting	Rifle: Centrefire	✓	✓	All higher cost	Non-toxic
	Rifle: Rimfire	✓	✓	All higher cost	Non-toxic
	Shotgun	✓	✓	All higher cost	Non-toxic
Shooting sports	Rifle /Handgun: Centrefire	✓	✓	All higher cost	Non-toxic
	Rifle / Handgun: Rimfire	✓	✓	All higher cost	Non-toxic
	Shotgun (trap and skeet, sporting clays); pellets for airguns[153]	✓	✓	All higher cost	Non-toxic

*A tick here indicates that available evidence indicates that equivalent performance can be obtained with appropriate choice of material for the end use and firearm, and with using appropriate adjustments for the non-lead alternative used. In some cases, alternatives can be used as 'drop-in' replacements with no changes whereas others require adjustments e.g. to cartridge load, velocity, firearm choke adjustments etc. to achieve desired performance. **Availability refers to the fact that the alternatives are manufactured by major manufacturers that supply the Canadian market, availability at the local level in some areas may currently be limited due to the fact demand for non-lead simply doesn't exist (outside of the legislated non-lead hunt) so it is not reliably stocked by retailers currently. Alternatives are all available for purchase online. The alternatives considered in the table above include ammunition based primarily on copper, steel, bismuth and tungsten. The primary alternatives are steel (shot) which is the most cost-effective non-toxic shot available and the most widely used currently, and bullets containing 90-100% copper.

Alternatives to lead are available as they are manufactured by all the major manufacturers that supply the Canadian market and increased demand could be met by increased supply.[154] Current availability at the local level in some areas may currently be limited due to the fact that most ammunition sold currently is traditional lead ammunition, and the demand for non-lead ammunition simply does not exist (outside of the legislated non-lead hunt), so it is not stocked in a wide range or reliably by retailers. Alternatives are all available for purchase online if not currently available at local stores.

Although the alternatives are all listed as associated with higher costs, this is a worst case assessment as this comparison is based on the cheapest options available in each category. Some alternatives are comparable in price if high-quality premium lead ammunition (i.e. the higher cost lead ammunition options available) is compared to the equivalent alternatives. This was also the conclusion of Thomas (2013), who found no major

[152] Regulatory submissions for approval as non-toxic ammunition require toxicity testing across two generations and assessment of metabolism, reproductive output, duckling growth and survival, and histological-pathological testing of tissues. In addition, potential toxicity to humans is also assessed including evaluation of the scenario when a human ingests some of the candidate shot along with the game meat and swallows the shot. This evaluation requires an assessment of solubility, assimilation, and effect on target organs following ingestion. The alternatives currently available (i.e. based on steel, bismuth, tungsten, copper) have all achieved this non-toxic designation.

[153] Alternatives to air gun pellets also include zinc-aluminium and tin based

[154] All major ammunition manufacturers already make the alternatives and could increase supply to meet increased demand (Ammunition manufacturer, pers. comm. 2016)

difference in the retail price of lead-free vs lead ammunition for equivalent high-quality popular calibres of ammunition used for hunting.[155] A comparison of lead shot ammunition with non-lead equivalents assumes that the lead counterpart is of high quality, as is required of all lead-free cartridges. Some cheap, lower quality component lead shot cartridges are imported into Canada, and retail for lower prices, therefore distorting any comparison of the costs of lead and lead-free ammunition.

Expenditures on ammunition by hunters and sport shooters are <4% and ~14%, respectively. Hence, ammunition is a relatively small portion of their annual expenditures.

The hunter survey (2017) asked respondents to describe their experiences with non-lead ammunition. This question was presented as an open text box as the Ontario Federation of Hunters and Anglers (OFAH) had suggested this format was more acceptable than the multiple choice answers that were originally proposed.[156] This open text format makes it difficult to quantify the responses but allows respondents to state any concerns/comments they have regarding non-lead ammunition. Responses indicated that many hunters/shooters have not tried non-lead ammunition. Many expressed concerns regarding cost, lack of local availability, and efficacy of non-lead ammunition. A few respondents indicated that they had tried non-lead ammunition and found it performed well.

Under 'Other comments' the vast majority of respondents that provided input (total responses 198) indicated that they did not believe that lead ammunition was an environmental or human health problem. Representative example responses included:

"I do not support any legislation requiring the use of non-lead ammunition for target shooting or hunting. Lead contamination is a much overblown issue and seems to be yet another way government is pondering to make the life of shooters more difficult in hopes they will give up the shooting sports"

"I feel lead ammunition in all cases other than water fowl has zero impact on the environment. I shoot it because it shoots well. I believe I should have the choice in ammunition's to use at my discretion, to take one away would be taking my freedom of choice."

"I state now that I am against removing lead bullets. I do not believe there is any urgent issues with using lead bullets for target and hunting. I know of no studies that say that animals and the environment are being effected by lead bullets used in target and hunting in anyway. I know of one in the last 40 years of hunting who has died or experienced lead issues regarding their health or from eating game."

"I believe the use of lead shot/bullets is way overblown by those with a anti gun/anti hunting agenda."

"I do not for one second believe that there is an ecological concern over using lead ammunition while hunting for big game, small game or upland game birds. I believe hunters and recreational shooters should have the choice of which ammunition they choose to shoot."

"Banning lead ammunition is absolutely moronic. People have got to have something better to do, and bigger problems to work on."

"lead in ammunition is not a problem, another back door attempt at gun control"

"lead contamination from shooting sports is a non issue and not a health hazard. It was not necessary for waterfowl and it certainly isn't for rifle, pistol and shotgunners. The amount of lead in the environment from firearms projectiles is miniscule - even on firearms shooting ranges. Unless one is ingesting dirt from the back stops, there is no health hazard. This issue is a "red herring" and is one more effort by anti gunners and anti hunters to place obstacles in the way of legitimate, lawful firearm use in Canada. Regulating lead projectiles as California has done is totally unnecessary. Population densities in Canada are so low that lead from firearms projectiles isn't even measurable. Attempts to further restrict lead ammunition will be rigorously opposed by the firearms community."

Most responses (>80%) under 'other comments' were similar to the above.

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[155] Thomas (2013) Lead-free hunting rifle ammunition: Product availability, price, effectiveness, and role in global wildlife conservation. AMBIO 2013, 42: 737-745

[156] OFAH provided input to the survey design and was provided with the final survey for distribution to their members. However, no responses were received from Ontario.

Relatively few respondents (<10%) indicated a recognition of the toxicity issues associated with lead, and/or a willingness to discuss the issue and/or switch to non-lead. Several of the respondents with this type of response noted concerns regarding accessing a reliable non-lead supply and cost e.g:

"You should know that these survey results have been highly biased by internet hunting and angling forums encouraging their members to skew their answers toward indicating that lead ammunition is not a conservation of food safety concern. Much is needed with respect to communication of the concerns of lead exposure to not only wildlife but also humans. The vast majority of hunters are not aware of the problem and are threatened by what they perceive to be attempts to restrict their ammunition choices."

"Overall I am in favour of moving away from lead ammunition."

"I'd be fine with a ban on lead ammo"

"As lead is toxic I would like to see it banned altogether, then alternatives would become easier to source and more available."

"My hunting partners and I switched to non-lead bullets due to concerns from lead in meat for consumption."

"If lead gets prohibited in hunting/shooting, I'm ok with it. But prices need to be the same and equally available as the lead shot now."

"I would happily switch to all lead free ammo if it was readily available, I am currently trying to source a reliable supply."

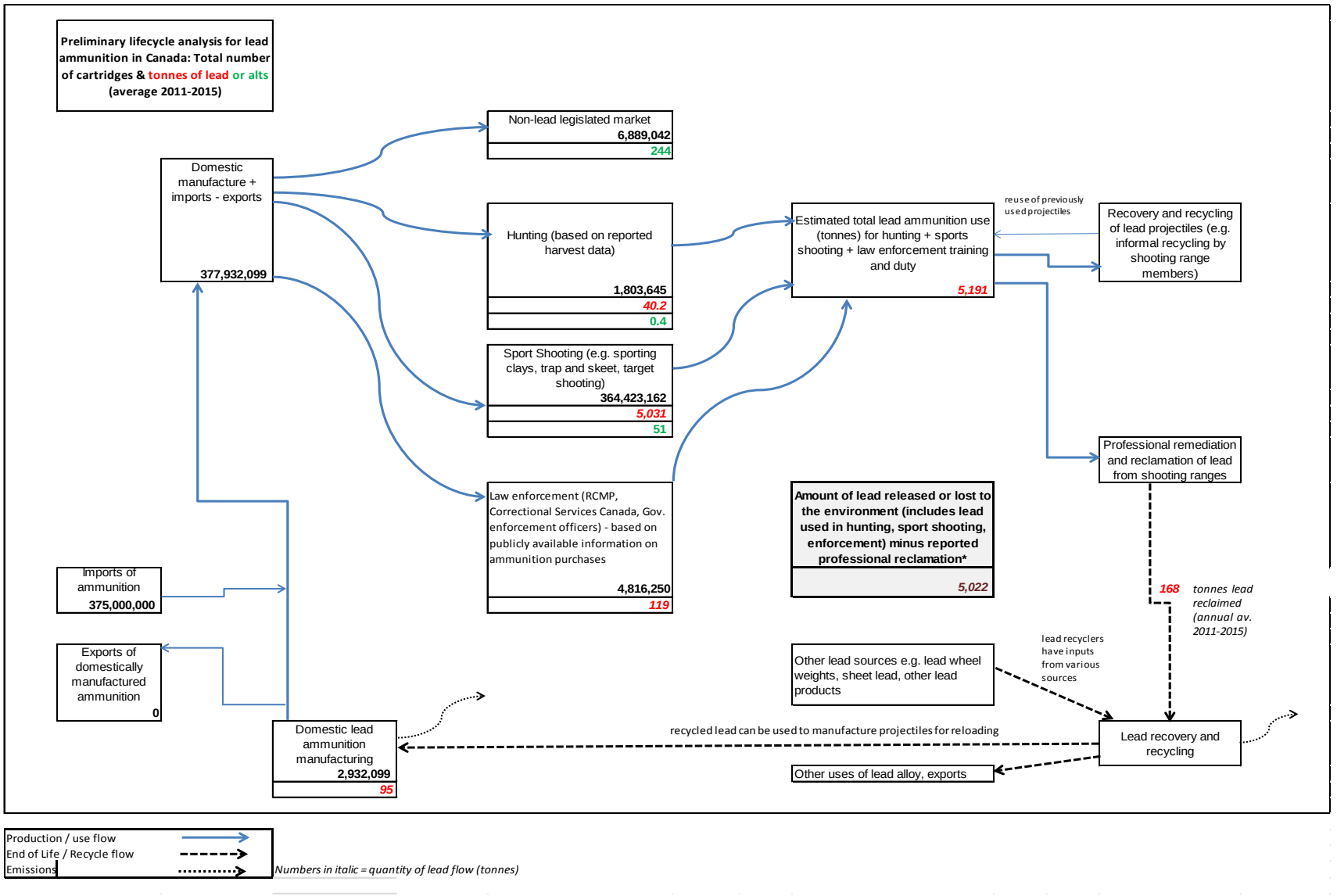
Recently, an ammunition retailer in Nova Scotia indicated that a wider ban on lead ammunition could fix the current supply-and-demand problem as this would be expected to make the production of non-lead ammunition more cost effective for manufacturers, and retailers would then be able to reliably stock non-lead ammunition as there would be a guaranteed market for the products.[157]

[157] Williams C. CBC News 16 March 2017. Hunters say non-toxic ammo hard to find as 7th lead-poisoned eagle found: http://www.cbc.ca/news/canada/nova-scotia/bald-eagles-lead-ammo-hunters-cobequid-wildife-rehabilitation-1.4025999

4.0 Lifecycle Analysis

Utilizing the data obtained and discussed in previous sections of this report, a lifecycle assessment was developed which is summarized in the following figure which illustrates the most likely or average scenario (see Figure 23). The following discussion provides details on the uncertainties and provides a range of lower and upper estimates to bound these uncertainties.

Figure 23. Lifecycle Analysis: Lead Ammunition (most likely scenario – refer to discussion for lower and upper-bounding estimates)



In the lifecycle diagram above it should be note that:

- The domestic manufacturers of lead shot in Canada did not report any exports and production serves only the domestic market.. Exports are currently stated as zero based on current reports. Some companies that specialize in military applications may have munitions exports but these fall outside the scope of this study. Domestic production and exports of non-military ammunition are minor – the vast majority of the market is due to imported ammunition.
- Responses from stakeholders consistently indicated that the only notable market for non-lead ammunition in Canada was the legislated non-lead hunt under the *Migratory Birds Convention Act*. Uses of non-lead ammunition outside this legislated market were said to be 'incidental'. In the analysis we have therefore assumed that virtually all ammunition used in hunting (outside legislated non-lead hunt) and sport shooting contains lead. To allow for minor uses of non-lead ammunition in the estimates (e.g. due to exchange programs such as the one in NS that offers the first box of copper hunting bullets in exchange for lead ones) we have adjusted the estimates to allow for a small amount (currently using a placeholder estimate of 1%) of the total to be non-lead.
- The estimated uses of ammunition for hunting outside of the legislated lead hunt may be an underestimate as not all harvest numbers or species are reported.
- The estimated uses of lead in the shooting sports is based on cartridge import data from NRCan and import data from CIMT combined with research on the most commonly used cartridge types for rifle/pistol and shotguns. There were insufficient data available from stakeholders to estimate this directly from Canadian sales and uses of ammunition. NRCan provided total number of cartridge imports into Canada but could not provide details on the number of each cartridge type imported which is important for estimating the mass of lead in the cartridge. For example, some of the commonly used rifle ammunition cartridges can contain up to ~3.6g lead per cartridge (.22, 55 grain) whereas commonly used larger grain bullets such as 147 grain can contain ~9.7g lead. The most commonly used shotgun cartridges contain 1oz to 1 7/8 oz of lead shot – with an average of 32.4 g per cartridge being commonly used in sporting clays, trap and skeet. Available import data from CIMT indicates that more rifle/pistol ammunition is imported than shotgun ammunition (based on value of imports) – with shotgun cartridges being ~30% of cartridge imports. Assuming that commonly used calibres of rifle/pistol ammunition ranging from 3.6g (e.g. .22 calibre, 55 grain) to 9.7g (e.g.147 grain) are representative of overall projectile mass for rifle/pistol ammunition imports we estimate that the average projectile mass per rifle/pistol cartridge would be ~ 7g per cartridge and CIMT data that indicates that rifle/pistol cartridges form 70% of imports (by value). We assume that the shotgun cartridges imported average 32.4g of projectile and CIMT data indicates they form 30% of imported cartridges. Overall, the average mass of projectile for all imported cartridges is 14.4 g and NRCan data indicates 375 million cartridges were imported resulting in 5391 tonnes of projectiles being imported (see Table 42). From this total we minus the estimated uses in hunting (both the lead hunt and the legislated non-lead hunt based on reported harvest data) and the ammunition purchases for enforcement activities (based on publicly available data on ammunition purchases by the RCMP, Correctional Services Canada and other enforcement agencies) to provide an estimate of expected total uses in shooting sports. There is insufficient data to breakdown this number into the amount of ammunition used for each type of shooting sport (e.g. sporting clays vs trap & skeet, target shooting etc.). Input from the NSSF confirmed that the vast majority of lead ammunition is consumed in shooting sports.
- Some shooting ranges reported informal recovery and recycling of lead ammunition by their members. Spent projectiles can, in some cases, be recovered and reused several times. In addition, some shooting range members melt down and recast lead projectiles and then re-shoot them. Although some of the spent lead projectiles can be informally recycled in this way it is assumed that they will ultimately be lost to the environment. There are insufficient data available to quantify this informal recycling activity.

Table 42. Estimated Mass of Projectiles in Imported Cartridges and Total used in Shooting Sports

Description	Estimate	Notes
Average mass of projectile in imported rifle/pistol cartridges (g)	6.7	Based on .22 calibre (55 grain) and 147 grain bullets being representative of the import mix and both are equally representative of the typical range of projectile mass in rifle/pistol cartridge imports
Average mass of projectile in imported shotgun cartridges (g)	32.4	Representative of average weight of shot in commonly used shotgun cartridges
Percentage of imports that are rifle/pistol	70%	CIMT data (publicly available data based on import value – quantity data not available)
Percentage of imports that are shotgun cartridges	30%	CIMT data (publicly available data based on import value – quantity data not available)
Average mass of projectile in imported cartridges (all types) (g)	14.4	Takes into account differing quantities of lead in cartridges and higher quantity of rifle/pistol cartridge imports vs shotgun
Total number of imported cartridges	375,000,000	Ammunition cartridge imports reported to NRCan[158] under the *Explosives Regulations*[159]
Total mass of projectile in imported cartridges (tonnes)	5391	Assuming average 14.4 g per cartridge and 375 million cartridges imported
Domestic production of lead shot (tonnes)	95	Reported to survey
Total mass of projectile in ammunition used in Canada – incl. imports and domestic production (tonnes)	5486	Total imported mass of projectiles plus domestic production
Total projectile mass used in hunting (tonnes)	244 (non-lead) and 40.6 (primarily lead)	Based on reported harvest data and assuming average of 3 shots per kill
Total projectile mass used in enforcement activities (tonnes)	119	Based on ammunition purchases
Total projectile mass used in shooting sports (tonnes)	5082	Total imported and domestically produced mass of projectiles minus total amount of projectiles used for hunting and enforcement (vast majority expected to be lead)

[158] NRCan pers. comm. 10 Nov 2016: Explosives Regulatory Division, ESSB
Natural Resources Canada / Government of Canada

[159] *Explosives Regulations, 2013* see section 46(1): 'An applicant for an import permit must complete, sign and send to the Chief Inspector of Explosives the application form provided by the Department of Natural Resources. The application must state whether a single use permit or an annual permit is requested and include the following information: …(c) the product name and UN number of each explosive to be imported, (d) the quantity of each explosive to be imported.' Note that a person may import up to 5,000 ammunition cartridges for personal use without an import permit (see Section 45). Note also that the *Explosives Act* does not apply to or in respect of any explosives under the direction or control of the Minister of National Defence.

Alternative methods using publicly available data can be used to estimate total uses of ammunition in shooting sports in Canada. Given the large contribution of the shooting sports sector to the total amount of lead used in ammunition in Canada, alternative estimates were examined to determine if consistent results were obtained using other approaches. Note also that CEPA section 71 data could also be obtained from stakeholders for this purpose.

Shooting sports – alternative approach A: Using data on participation levels at shooting ranges: For example, we have estimated that there are ~227,010 shooting range members in Canada. Available information indicates that the average shooter visits the range 22 times per year and discharges between 50 and 100 rounds per visit on average. We do not have detailed data available to us on the exact mix of ammunition used on Canadian ranges, but estimates developed in this report indicate that the mix of ammunition used in terms of cartridge quantities is approximately 30% shotgun to 70% rifle/handgun (e.g. based on available import data) with projectile mass of each cartridge ranging from ~3.6g to 36g per cartridge. Based on the most popular rifle/handgun and shotgun cartridges used, we have estimated that the average mass of projectile per cartridge is 14.4g. Using this information, we estimate the amount of ammunition that would be expected to be used on average by shooting range members in Canada each year – low, medium, and high scenarios were developed by varying only one of the variables - the average number of cartridges used each visit was varied from 50 to 100 (see Table 43).

Table 43. Estimated use of ammunition by shooting range members in Canada

Scenario	Low	Medium	High
Range members (#)[160]	227,010	227,010	227,010
Average visits per year (#)[161]	22	22	22
Average number of cartridges used per visit (#)	50	75	100
Total number of cartridges discharged per year (#)	249,711,000	374,566,500	499,422,000
Average projectile mass per cartridge – all sports combined (g)	14.4	14.4	14.4
Total mass of projectiles used per annum (tonnes)	3,590	5,384	7,179

The medium scenario using this alternative approach is very similar to the estimate developed using import data from NRCan, and then removing expected uses in hunting and law enforcement (see section 3.2.5). Note that this approach assumes that the only people that use shooting ranges are range members.

Shooting sports – alternative approach B: Another alternative approach is to use data in the literature from other jurisdictions that have developed estimates of average lead ammunition uses per hunter/shooter. In this regard, it has been estimated that on average European hunters/shooters use 6.122kg of lead per year in ammunition (Thomas and Guitart, 2010). We can use this estimate, with data on the number of firearms licences in Canada, to estimate total lead uses in ammunition. Since there are 1,989,181 firearms licences in Canada, this indicates that uses of lead in ammunition would be expected to be ~12,000 tonnes per year (hunters and sports shooters combined). This approach assumes that every individual with a firearms licence in

[160] Estimated from available data on shooting ranges in Canada from publicly available information, consultations, and RCMP data from ATIP. See Table 22 in this report

[161] Southwick Associates (2013) Target Shooting in America. Report produced for the National Shooting Sports Foundation (NSSF)

Canada is an active hunter/shooter and we do not expect this to be the case. In addition, comparing this total to the number of cartridges imported per year (375 million) indicates that the average projectile mass per cartridge would be ~30g – this would be reasonable if the vast majority of cartridges imported were shotgun cartridges – but we know that this is not the case. We expect that the majority of cartridges imported are rifle/handgun cartridges that contain on average <15 g lead per cartridge. We do not recommend this approach as it results in an overestimation of the amount of lead used in shooting sports and hunting in Canada.

We therefore conclude that the most likely scenario is that ~5000 tonnes of lead are used per year in shooting sports in Canada. A reasonable range bounding the uncertainties would be the low, medium, and high scenario shown in Table 43 above developed using the number of shooting range members and average shooting range participation data i.e. average/most likely = 5000 tonnes (range of uncertainty:~3500 tonnes to ~7000 tonnes).

Table 44 summarizes the range of estimates for lead uses in ammunition in Canada in hunting and shooting sports. These estimates bound the uncertainties in the analysis. These uncertainties could be reduced with greater input from stakeholders in the ammunition market (e.g. via use of a CEPA Section 71 survey).

Table 44. Quantity of Lead used in Ammunition in Canada: Shooting Sports and Hunting (tonnes per annum)

Scenario	Low	Medium	High
Shooting Sports	3,500	5,000	7,000
Hunting	14	40	80

Note: Numbers are rounded. Hunting range is based on 1 to 6 shots per reported kill based on publicly available harvest data. The low estimate for hunting is considered unlikely as this would require every hunter to be a perfect shot (1 shot per reported kill); in addition reported harvest data is not expected to cover all species that are shot with lead ammunition. The medium hunting estimate is based on 3 shots per reported kill, and the high estimate is based on 6 shots per reported kill. The hunting estimates exclude all species covered by the legislated non-lead hunt and assumes 100% compliance by hunters with these regulatory requirements.

The medium scenario is considered the most likely and is the one illustrated in more detail in the flow analysis figure (see Figure 23).

4.1 Releases of Lead on Shooting Ranges

Outdoor Ranges: The lifecycle analysis indicates that the majority of lead ammunition used in Canada is discharged on shooting ranges. Available information indicates that the majority of lead ammunition discharged at shooting ranges in Canada is not recovered or reclaimed and hence is lost to the environment. It is noted in the literature that outdoor shooting ranges are renowned for their extremely high metallic lead burdens in soil (Darling and Thomas, 2005).[162]

Previous studies have concluded that the species most likely to be at risk through direct ingestion of spent lead or contaminated soil on or near shooting ranges are waterfowl, mourning doves, and other species that forage on the ground or use grit to help aid in digestion[163]. Darling and Thomas (2003) noted that if the shot impact zone on a shooting range coincides with a wetland, there is the risk of direct ingestion of lead shot by bottom-

[162] Thomas and Darling (2005). Lead bioaccumulation in earthworms, *Lumbricus terrestris*, from exposure to lead compounds of differing solubilities. Sci. Tot. Environ. 346, 70-80

[163] Golden *et al* (2016). A review and assessment of spent lead ammunition and its exposure and effects to scavenging birds in the United States. In: Reviews of Environmental Contamination and Toxicology (P.de Voogt (ed)). Volume 237. 123-191

feeding birds as well as water pollution – the authors found that 47 ranges out of 50[164] in Ontario contained open water (rivers, lakes, ponds and streams).[165]

Lead poisoning has been documented in northern pintails that foraged in a tidal meadow contaminated with lead from a trap and skeet shooting range (Roscoe *et al.* 1989).[166] Greater lead exposure was found in passerines that foraged on the ground near a small-arms range as compared to those in a wildlife habitat a distance from the range (Vyas *et al.* 2000).[167] The likelihood of scavenging birds that normally feed on live or dead animals to directly ingest contaminated soil or spent lead shot from the ground is low. However, scavengers could become exposed through consumption of prey items that have directly ingested spent lead shot or contaminated soil from shooting ranges (Golden *et al*., 2016).[168] Lead poisoning of farm animals (hens, ducks, and cattle) raised on land adjacent to clay pigeon shooting ranges has been reported (Payne *et al* 2013).[169]

Although some of the lead deposited on shooting ranges may remain in pellets in the soil, part of it is continuously transformed due to physical disintegration and chemical reactions into soluble forms that have the potential to bioaccumulate and cause biological effects (Rantalainen *et al.,* 2006).[170] Soil microbial communities and soil fauna (including the enchytraeid worm *Cognettia shagnetorum* – proposed as a keystone species of boreal forest due to its importance in nutrient mineralization) were found to be adversely impacted at the site of an old shooting range contaminated with lead compared to a control site.[171] A study on the fate of lead from shotgun pellets on a Finnish shooting range found that the lead mobilized into the humus layer and was taken up by plants; lingonberries in the area had a lead content of 0.3 mg/kg and exceeded allowable lead levels according to Finnish food safety regulations.[172]

Reid and Watson (2005) found soil levels of 6,410 +/- 2,250 and 296 +/- 98 mg(Pb)/kg dw, respectively at a clay-pigeon shooting site soil and a control site. At the shooting range body burdens of earthworms were almost 1,000 times higher than those from the control site.[173] Rodriguez-Seijo *et al* (2016 and 2017) found high concentrations of lead in the soil at an abandoned shooting range in Spain which exceeded limit values for urban soils[174] - even soils far away from the firing positions exceeded the limits established by the US EPA (400 mg Pb/kg).[175] The authors found that the elevated lead levels in the soil from the shooting ranges were associated with lead bioaccumulation and adverse impacts on reproduction in earthworms.[176] Bioaccumulation of lead by earthworms at shooting ranges can result in increased body burdens of lead in species that feed on earthworms such as amphibians, reptiles, birds, and small carnivorous mammals (Thomas and Darling, 2005).

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[164] Darling and Thomas (2003) found that 50 of the ranges in Ontario had had sufficient locational information available to determine the range boundaries – of these, 47 contained a water body

[165] Darling and Thomas (2003). The distribution of outdoor shooting ranges in Ontario and the potential for lead pollution of soil and water. Sci. Tot. Environ. 3131, 235-243

[166] Roscoe DE, Widjeskog L, Stansley W (1989) Lead poisoning of northern pintail ducks feeding in a tidal meadow contaminated with shot from a trap and skeet range. Bull Environ Contam Toxicol 42:226–233

[167] Vyas NB, Spann JW, Heinz GH, Beyer WN, Jaquette JA, Mengel-Koch JM (2000) Lead poisoning of passerines at a trap and skeet range. Environ Pollut 107:159–166

[168] Golden *et al*. 2016.A review and assessment of spent lead ammunition and its exposure and effectsto scavenging birds in the United States. Revs Environ Contam Toxicol 237:123-191

[169] Payne *et al* (2013) Lead intoxication incidents associated with shot from clay pigeon shooting. Veterinary Record December 7, 2013 published by the British Medical Journal: doi:10.1136/vr.102120

[170] Rantalainen *et al* (2006) Lead contamination of an old shooting range affecting the local ecosystem – A case study with a holistic approach. Sci. Tot. Environ. 369: 99-108

[171] Ibid

[172] Manninen and Tanskanen (1993) Transfer of lead from shotgun pellets to humus and three plant species in a Finnish shooting range. Arch. Environ. Contam. Toxicol. 24: 410-414

[173] Reid and Watson (2005)**.** Lead tolerance in (*Aporrectodea rosea*) earthworms from a clay pigeon shooting site. *Soil Biology and Biochemistry* 37(3), 609-612

[174] Spanish Generic Reference Level (GRL) of 100 mg/kg for lead

[175] US EPA 2001. Lead: Identification of dangerous levels of lead, Final Rule 40CFR Part 745.

[176] Rodriguez-Seijo *et al* (2016). Pb pollution in soils from a trap shooting range and the phytoremediation ability of *Agrostis capillaris* L. Environ. Sci. Pollut. Res. 23, 1312-1323; Rodriguez-Seijo *et al* (2017) Lead and PAHs contamination of an old shooting range: A case study with a holistic approach. Sci. Tot. Environ. 575, 367-377.

For example, white-footed mice *Peromyscus leucopus* and green frogs *Rana clamitans* sampled within the impact zone of a shooting range with high pellet density had depressed ALAD enzyme levels (Stansley and Roscoe 1996)[177], a recognized indicator of sub-clinical lead toxicosis in mammals, and the mice also had reduced haemoglobin levels. Stansley *et al.* (1997) found high mortality in eggs of pickerel frogs *Rana palustris exposed* to lead contaminated surface water from a trap and skeet range. In this study, the lead concentration in the shooting range run-off water was found to be 3,150 µg Pb/l and 100% mortality was observed after 10 days of exposure.[178] Lewis *et al* (2001) found elevated tissue lead levels and confirmed lead toxicosis in wild avian and mammalian species at a firearms training facility in the US.[179] Mariussen *et al* (2017) found elevated lead levels in the tissues of brown trout (*Salmo trutta*) in a lake downstream of a former shooting range in Norway.[180]

When lead shot and lead ammunition fragments enter the soil, weathering processes start and elemental lead is transformed through oxidation, carbonation, and hydration into dissolved and particulate lead species. Hardison *et al* (2004) quantified the amount of lead that is physically abraded as a lead rifle bullet passes through berm soil at a shooting range generating fine lead powder – and found that 1.5% of the bullet mass is immediately abraded as it passes through the berm. The authors then studied the weathering rate of the fine metallic lead that is released and found it was rapidly converted from to more reactive lead minerals (primarily hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), and to a lesser extent $PbCO_3$ and PbO) within 7 days. The authors noted that these lead minerals may pose a risk to groundwater contamination in shooting range soils.[181] Surface water samples from a rifle and shotgun range in SW Virginia (USA) were found to contain elevated lead concentrations with samples taken closest to the ammunition impact areas containing lead levels 50 to 100 times the median value for natural waters.[182] Murray *et al* (1997) also found surface water concentrations at an outdoor shooting range in Michigan (USA) to be 10 to 100 times greater than background concentrations. In addition, Murray *et al* (1997) found lead contamination of subsurface soils, which spatially correlated with highest lead contamination by lead shot at the surface, and the presence of water-soluble lead compounds, indicating lead being mobilized from the pellets and leached downwards – despite the clay-rich nature of the soil.[183] Agricultural soils close to shooting ranges have been shown to elevated lead levels, with isotopic analysis confirming the contamination originated from ammunition; Chrastny *et al* (2010) found that >60% of the lead in the contaminated soil was found to be potentially mobilizable, and crops grown on the soil had increased lead content.[184]

Lead mobility in soils is determined by soil pH, and the clay and organic content of soil, which are factors which will vary between shooting range location. Darling and Thomas (2003) reviewed this aspect of shooting ranges in Ontario found that 17 shooting ranges had low pH soil types and that 7 of these also had low organic matter content – these soil conditions are conducive to enhanced dissolution of metallic lead and higher lead mobility in soil. The soils at some shooting ranges are expected to exhibit a greater potential for mobilizing lead e.g. in Ontario those in the central and Northern regions of the province where brunisolic and podzolic soils predominate (Darling and Thomas, 2003). It should be noted that other studies on shooting ranges have indicated that lead is bioavailable even in cases where soil properties would be expected to limit lead mobility (e.g. pH is slightly alkaline) – for example, vegetation and earthworms collected from various sites on a shooting range with varying pH levels all showed elevated lead concentrations (reviewed by Darling and Thomas, 2003).

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[177] Stansley and Roscoe (1996). The uptake and effects of lead in small mammals and frogs at a trap and skeet range. Archives of Environmental Contamination and Toxicology 30(2), 220-226.

[178] Stansley *et al.,* (1997). Effects of lead-contaminated surface water from a trap and skeet range on frog hatching and development. Environmental Pollution 96(1), 69-74

[179] Lewis *et al* (2001) Lead toxicosis and trace element levels in wild birds and mammals at a firearms training facility. Arch. Environ. Contam Toxicol. 41: 208-214

[180] Mariussen *et al* (2017) Accumulation of lead (Pb) in brown trout (*Salmo trutta*) from a lake downstream a former shooting range. Ecotoxicology and Environmental Safety 135: 327-336

[181] Hardison et al (2004) Lead contamination in shooting range soils from abrasion of lead bullets and subsequent weathering. Sci. Tor. Environ. 328: 175-178

[182] Craig *et al* (1999) Surface water transport of lead at a shooting range. Bull. Environ. Contam. Toxicol. 63: 312-319

[183] Murray *et al* (1997) Distribution and mobility of lead in soils at an outdoor shooting range. Journal of Soil Contamination 6:1, 79-93.

[184] Chrastney *et al* 2010 Lead contamination of an agricultural soil in the vicinity of a shooting range. Environ. Monitor. Assess. 162: 37-46

A recent study has indicated that biodegradable targets used for trap and skeet shooting that contain high levels of sulfur may lower the soil pH on ranges, and hence increase the mobility of lead from shotgun pellets.[185]

Pain *et al* (2015) reviewed the literature regarding lead shot deposition at shooting ranges and noted the potential for a "historical legacy" of lead shot remaining available to wildlife – it has been estimated that it takes >25-46 years for lead shot deposited on soil to sink to depths where it would not be available to waterfowl.[186] Pain *et al* (2015) noted that while a historical legacy of deposited gunshot exists, there is good evidence that the majority of gunshot ingested by wildfowl is that of most recently deposited. For example, Anderson *et al.* (2000) found that in the fifth and sixth years after a nationwide ban on the use of lead gunshot for shooting waterfowl in the USA, 75.5% of 3,175 gunshot ingested by a sample of 15,147 mallard ducks on the Mississippi flyway were non-toxic. This indicates that the benefits of replacing lead with non-toxic alternatives on shooting ranges, in terms of reduced wildlife toxicity, could be realized in a relatively short time-frame.

Indoor Ranges: Releases of lead occur during use of lead ammunition at indoor firing ranges and can result in elevated levels of lead in air and dust at shooting ranges. Potential lead exposure of recreational shooters was recently reviewed by Public Health Ontario (PHO), focusing specifically on indoor shooting ranges[187]. This study was initiated when a male patient, who was a sports shooter in Ontario, presented with blood levels of 12 µg/dL, which exceeded the blood lead intervention level set by Heath Canada at 10 µg/dL. PHO conducted an exposure assessment at the shooting range and found that 4 out of 5 breathing zone samples performed on the shooters exceeded Ontario's occupational exposure limit of 50 $\mu g/m^3$ (8h time-weighted average (TWA)). This indicated the inadequacy of the existing ventilation system to reduce airborne lead generated during shooting. Wipe and vacuum samples also showed the presence of lead in 8 of 9 surfaces tested. Lead dust at ranges can be easily transferred to hands, which can result in ingestion, and to clothes that can result in 'take-home lead' exposure of family members outside the range environment. The PHO study concluded that elevated blood lead levels in occupationally exposed workers at firing ranges are well documented and that exposure can occur at ranges run by volunteers where regulations related to worker exposure may not apply. As many ranges serve a social function, as well as a place to practice shooting, children as well as adults may be present.

The US Centers for Disease Control and Prevention (CDC) estimated that recreational target shooting was the likely source of lead exposure for 2,673 of 9,044 persons with elevated BLLs (1,290 with BLLs >25ug/dL and 1,388 with BLLs of 10-24 ug/dL).[188] Several studies have shown elevated BLLs in children and young adults who practice shooting at indoor ranges. For example, Shannon (1999) found BLLs of 18-28 ug/dL in adolescent girls who were competitive shooters even though health and safety measures (including hand washing and clothing changes) had reportedly been followed[189]. A study in Alaska found elevated BLLs among students (aged 7-19 years; mean BLLs ranged from 7.6 ug/dL to 24.3 ug/dL) on shooting teams at 4 out of 5 indoor ranges assessed.[190]

As a result of the exposure assessment and literature review, PHO developed a list of preventative measures to reduce the risk of lead exposure at indoor ranges which included:

1. Encouraging the use of lead-free ammunition.
2. Adequate ventilation systems should be installed and maintained.

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[185] McTee *et al* (2016) Extreme soil acidity from biodegradable trap and skeet targets increases severity of pollution at shooting ranges. Science of the Environment 539: 546-550.

[186] Pain *et al* (2015) Poisoning of birds and other wildlife from ammunition-derived lead in the UK. Proceedings of the Oxford Symposium: Lead Ammunition: Understanding and minimising the risks to human and environmental health. Delahay and Spray (Eds) p58-84

[187] Ontario Agency for Health Protection and Promotion (Public Health Ontario) 2014: Lead exposures among recreational shooters, Toronto ON 2014 ISBN: 978-1-4606-4737-0.

[188] Beaucham et al., 2014. Indoor firing ranges and elevated blood lead levels – United States, 2002-2012. MMWR Morb Mortal Wkly Rep 2014; 25;63(16): 347-51 (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6316a3.htm)

[189] Shannon 1999. Lead poisoning in adolescents who are competitive marksmen. N. Engl. J. Med. 1999; 9; 341(11): 852.

[190] Ramsey et al., 2013. Health hazard evaluation report: Followback evaluation of lead and noise exposures at an indoor firing range. http://www.cdc.gov/niosh/hhe/reports/pdfs/2012-0065-3195.pdf

3. Education of shooters and volunteers at the range regarding lead toxicity and the potential exposure from lead dust. Activities such as eating and drinking and dry sweeping should not be allowed, and shooters should be encouraged to change clothes/shower after shooting or performing housekeeping or maintenance activities.
4. Regular testing for lead levels should be conducted.
5. Personal protective equipment should be used when cleaning lead contaminated areas.
6. Recycling or casting bullets should not be done onsite unless performed in a workshop designed to reduce lead exposure.

Hence, outdoor shooting ranges and indoor ranges may have differing environmental and human safety priorities regarding lead - with indoor shooting ranges being less of a concern for environmental contamination and wildlife toxicity vs outdoor ranges (assuming appropriate disposal of spent lead ammunition) but more of a concern for human exposure to airborne lead and dust.

4.2 Releases of Lead associated with Hunting

As stated earlier, there is increasing awareness that consuming game meat can result in elevated blood lead levels due to lead contamination of the meat from ammunition fragments.[191] Recent studies in Quebec indicated that lead exposure through game meat consumption, where the animal has been killed with lead ammunition, is a significant concern for susceptible subpopulations (e.g. children and pregnant women), particularly those relying heavily on game meat (Fachehoun *et al*., 2015).[192] Several case studies have also been reported where small children with elevated blood lead levels were found to have lead gunshot trapped in their appendix, the gunshot originating from game meat regularly eaten by the family.[193]

In addition, wildlife toxicity is also a concern associated with lead ammunition used in hunting. For example, the history of the recognition of poisoning of wild birds through the ingestion of spent lead shot is summarized by Pain *et al.* (2015). Ingestion of lead ammunition or ammunition fragments by predatory and scavenging birds has been reported for decades. Some of the earliest studies involved the poisoning of bald eagles *Haliaeetus leucocephalus*, which frequently feed on wildfowl in the USA (e.g. Feierabend and Myers 1984,[194] Reichel *et al.* 1984),[195] golden eagles (Craig *et al.* 1990)[196] and the California condor *Gymnogyps californianus*, a critically endangered species whose remaining population in the wild was almost driven to extinction by lead poisoning caused by scavenging upon discarded gut piles and carcasses of large game animals such as deer (Rideout *et al.* 2012).[197] Numerous studies have reported ingestion of ammunition derived lead in white-tailed eagles (*e.g.*

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[191] For example, see Couture *et al.,* 2012. Lead exposure in Nunavik. Intl J Circumpolar Health 71; Levesque et al., 2016 Monitoring of umbilical cord blood lead levels and sources assessment among the inuit. Occup Environ Med 2003: 60: 693-695; Verbrugge *et al*., 2009 Human exposure through ammunition in the circumpolar north; Lindboe *et al*., 2012 Lead concentration in meat from lead-killed moose and predicted human exposure. Food Addit. Contam. 1-6; Hung *et al*., 2009 Lead bullet fragments in venison from rifle-killed deer: Potential for human dietary exposure. PLoS ONE 4(4): e5330

[192] Fachehoun *et al*., 2015. Lead exposure through consumption of big game meat in Quebec, Canada: risk assessment and perception. Food Additives & Contaminants: Part A. 32:9, 1501-1511

[193] Zardari and Siriweera 2013 Pellets in the appendix. New England Journal of Medicine N Engl J Med 2013; 369:e7August 8, 2013 DOI: 10.1056/NEJMicm1214754; Cox and Pesola 2006 (and response from Schep and Fountain 2006) Lead Shot in the Appendix, N Engl J Med 2006; 354:1757April 20, 2006 DOI: 10.1056/NEJMc060133; Source of boy's mysterious lead poisoning was in an unlikely place. Livescience August 15, 2013: http://www.livescience.com/38914-mysterious-lead-poisoning-pellets.html

[194] Feierabend and Myers (1984). *A national summary of lead poisoning in bald eagles and waterfowl*. National Wildlife Federation: Washington, DC.

[195] Reichel *et al* (1984). Pesticide, PCB, and lead residues and necropsy data for bald eagles from 32 states-1978–81. *Environmental Monitoring and Assessment* 4(4), 395-403.

[196] Craig *et al* (1990). Lead concentrations in golden and bald eagles. *The Wilson Bulletin* 102(1), 130-133.

[197] Rideout *et al*., (2012). Patterns of mortality in free-ranging California condors (*Gymnogyps californianus*). Journal of Wildlife Diseases 48(1), 95-112.

Kenntner *et al.* 2001[198] in Germany and Austria, Helander *et al.* 2009 in Sweden[199]), and in a proportion of the carcasses of both this species and of Steller's sea eagles *Haliaeetus pelagicus* and mountain hawk eagles *Spizaetus nipalensis* in Hokkaido, Japan (Saito 2009).[200] Several methods exist to ascertain the origin of tissue lead concentrations in lead-poisoned birds. The most detailed isotopic studies have been conducted on California condors and they indicated that elevated lead exposure in condors is consistent with lead from ammunition rather than other sources (Church *et al.* 2006,[201] Finkelstein *et al*. 2010, 2012,[202] Rideout *et al*. 2012). Legagneux *et al.* (2014) found that blood lead concentrations in the raven, a scavenging species, increased over the moose hunting season in eastern Quebec, Canada, and that the birds with elevated blood lead levels had isotopic signatures that tended towards those of ammunition.[203] Pain *et al* (2015) estimated that 73,750 birds die each year in the UK due to lead poisoning associated with ingestion of spent lead gunshot.[204]

4.3 Projections

Projections on the expected uses of lead and non-lead ammunition in Canada were developed for the next ten (10) years 2016-2025. These projections were based on available data. Information on sales of specific cartridge types in Canada is not available to us as the vast majority of stakeholders with access to this information (i.e. ammunition manufacturers, importers, distributors, retailers and end users) refused to cooperate in providing information for this study. The projections provided here are based on publicly available information on ammunition manufacturing, imports, and uses in Canada, which is limited in scope. In addition, publicly available data from other jurisdictions on trends related to ammunition were reviewed and included in the analysis where appropriate. If ECCC utilizes CEPA section 71 to obtain further data from stakeholders involved in the ammunition sector these projections could be further refined using these data if necessary.

Projections are based on a Business-As-Usual (BAU) scenario assuming no additional management measures are applied to ammunition beyond those that exist today.

The following trends are taken into account in the projections:

- Shooting sports have increased in popularity over the last 5 years and this trend is expected to continue, although the double digit increases seen at some shooting ranges in Canada in the last 5 years would not be expected to continue for the next ten years. As the market becomes more saturated, growth rates would be expected to slow down. Some limiting factors to continued growth include the fact that some shooting clubs are operating at capacity and are not accepting new members, and some outdoor ranges are being increasingly encroached by residential development and would not be able to expand to accommodate higher membership numbers at their current

[198] Kenntner *et al* (2001). Heavy metals in soft tissue of white-tailed eagles found dead or moribund in Germany and Austria from 1993 to 2000. *Environmental Toxicology and Chemistry* 20(8), 1831-1837.
[199] Helander et al (2009) Ingestion of lead from ammunition and lead concentrations in white-tailed sea eagles (*Haliaeetus albicilla*) in Sweden. *Science of the Total Environment* 407(21), 5555-5563.
[200] Saito (2009) Lead poisoning of Steller's sea-eagle (*Haliaeetus pelagicus*) and whitetailed eagle (*Haliaeetus albicilla*) caused by the ingestion of lead bullets and slugs. In: Watson RT, Fuller M, Pokras M, Hunt WG (eds). *Ingestion of lead from spent ammunition: implications for wildlife and humans*. The Peregrine Fund, Boise, Idaho, USA. pp 302-309.
[201] Church *et al* (2006) Ammunition is the principal source of lead accumulated by California condors re-introduced to the wild. *Environmental Science & Technology* 40(19), 6143-6150.
[202] Finkelstein et al (2010) Feather lead concentrations and 207Pb/206Pb ratios reveal lead exposure history of California condors (*Gymnogyps californianus*). *Environmental Science & Technology* 44(7), 2639-2647 & Finkelstein *et al* (2012) Lead poisoning and the deceptive recovery of the critically endangered California condor. *Proceedings of the National Academy of Sciences* 109(28), 11449-11454.
[203] Legagneux *et al* (2014). High risk of lead contamination for scavengers in an area with high moose hunting success. PLoS ONE 9(11), e111546.
[204] Pain *et al*. 2015. Poisoning of birds and other wildlife from ammunition-derived lead in the UK. In: R.J. Delahay and C.J. Spray (Eds.). Proceedings of the Oxford Lead Symposium. Lead Ammunition: understanding the risks to human and environmental health, December 8, 2014. The University of Oxford, Edward Grey Institute.

locations. New ranges, however, could be built in alternative locations to accommodate increased interest in the sport. A few Canadian ranges provided data on participation rates – these responses indicated that participation rates had declined (1 range in a town where the major employer had shut down), stayed steady (1 range), or increased (5 ranges) with increases over the past 5 years being described as 'continual increase over the past 5 years', 'very large increase', '10% increase', 'double digit increase'. Data from the US also shows increased participation in the shooting sports in recent years with an overall increase of 3.4% per year between 2012 and 2014 (NSSF, 2015). In addition, it has been predicted that revenues of the US firearms and ammunition industry will increase by 2% per year during the period 2016-2020, and ammunition manufacturers expect increased sales due to increased participation in the shooting sports. Taking into account the available Canadian and US data on trends in shooting sport participation in recent years we have assumed an increase of 2% per year 2016-2020 consistent with the average of current trends, and then a lower growth of 1% per year from 2021-2025 assuming the market starts to experience some saturation.

- It is expected that ammunition purchases by sports shooters are to replace spent ammunition. However, as stated above, the number of sport shooters is increasing as the sport grows in popularity. Hence, ammunition purchases by this group are expected to increase with increased participation over the next 10 years. We have assumed that ammunition consumption rates directly follow trends in participation rates (i.e. if participation increases by 2% then ammunition consumption increases by 2%).
- It is expected that ammunition sales for hunting and law enforcement are at steady-state with ammunition purchases replacing ammunition used. Hunting levels have been steady over the last 5 years and are expected to remain steady over the next ten years with no major increase or decrease in ammunition consumption.
- There is no evidence of major increases or decrease in law enforcement expenditures in ammunition over the last 5 years. Hence, it is also assumed that ammunition uses in this sector remain steady over the next ten years.
- There is evidence of ammunition hoarding activities in the US typically linked to various factors including: (1) ammunition supply issues/shortages due to manufacturers being unable to meet demand for specific ammunition types, (2) political climate considered 'anti-gun', (3) panic buying following gun attacks, (4) fear about potential regulation/restrictions/taxes impacting ammunition cost/availability.[205] Ammunition hoarding in the US has the potential to impact supplies of ammunition in Canada with US-manufacturers prioritizing domestic demand at times of limited supply. Major Canadian retailers sometimes struggle to keep shelves stocked with ammunition to fully meet demand in Canada particularly at times when hoarding activities are occurring in the US.[206] Canadian gun owners have been reported to hoard ammunition based on rumours of a potential shortage of supply from the US.[207] Hoarding activities may result in temporary accumulations of ammunition by certain individuals during periods of time where there is uncertainty regarding supply. However, over extended periods of time, overall ammunition purchases are expected to simply replace spent ammunition on an ongoing basis. We have not included the impact of potential hoarding behaviours in the projections.
- Traditional lead ammunition continues to dominate the ammunition market and there is strong resistance to change amongst stakeholders. The only real market in Canada for non-lead ammunition currently is the legislated non-lead market under the *Migratory Birds Convention Act*. This situation is expected to remain largely unchanged in the absence of any new management measures directed at lead ammunition uses in Canada. We have therefore assumed that the market share of lead vs non-

[205] Weinstein, A., 2015. Sometimes there's a perfectly logical reason for hoarding ammo. The Trace: https://www.thetrace.org/2015/08/hoarding-ammo-ammunition-economics-guns-walmart/

[206] Canadian Tire, pers.comm. 2016

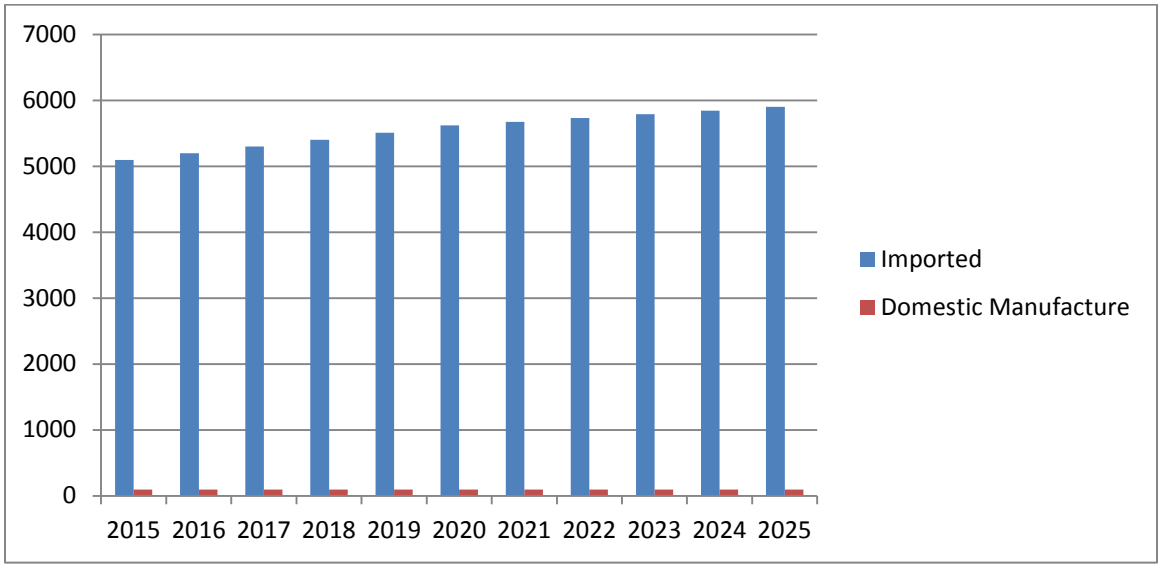
[207] Dyck, T. 2015. Canadian gun owners hoard bullets in face of feared shortage of ammunition from U.S. National Post, May 18, 2015: http://news.nationalpost.com/news/canada/canadian-gun-owners-hoard-bullets-in-face-of-feared-shortage-of-ammunition-from-u-s

lead ammunition within each activity (hunting, law enforcement, sport shooting) remains unchanged over the next ten years.

- Any increased demand for non-military ammunition over the next decade is expected to be met with imported ammunition. Minimal domestic manufacturing of ammunition occurs in Canada and most demand is met with imports from the US (>90%). This situation is expected to remain unchanged over the next ten years.

The projections are summarized in Figure 24-26.

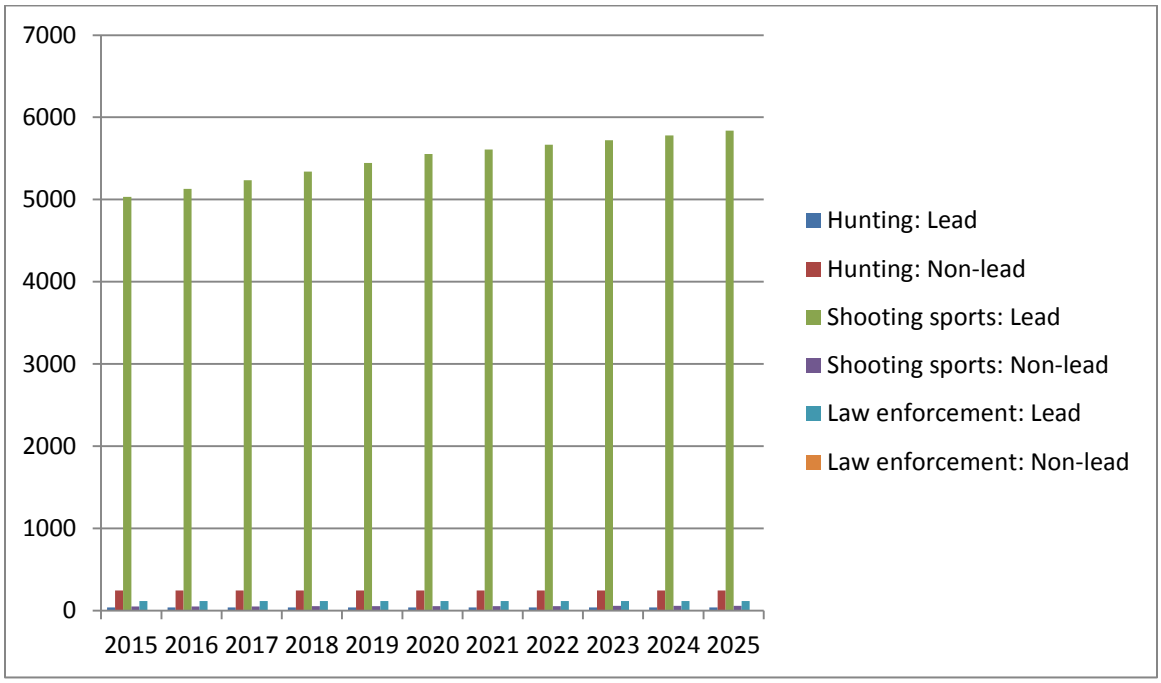
Figure 24. Projections for total quantity of lead in ammunition imported and domestically manufactured in Canada 2015-2025 (tonnes)



Note: Based on tonnes of projectiles

Uses of lead ammunition for hunting and law enforcement activities are assumed to be at steady state and not expected to show significant increases over the 2015-2025 period. Increased consumption of lead ammunition in shooting sports is responsible for the projected increase in lead ammunition demand shown in the above figure (see Figure 25 for a further breakdown). The increased demand is expected to be met with imported products. Between 2016 and 2025, the imports of lead in ammunition are expected to increase from ~5000 tonnes per year in 2016 to ~5900 tonnes per year in 2025.

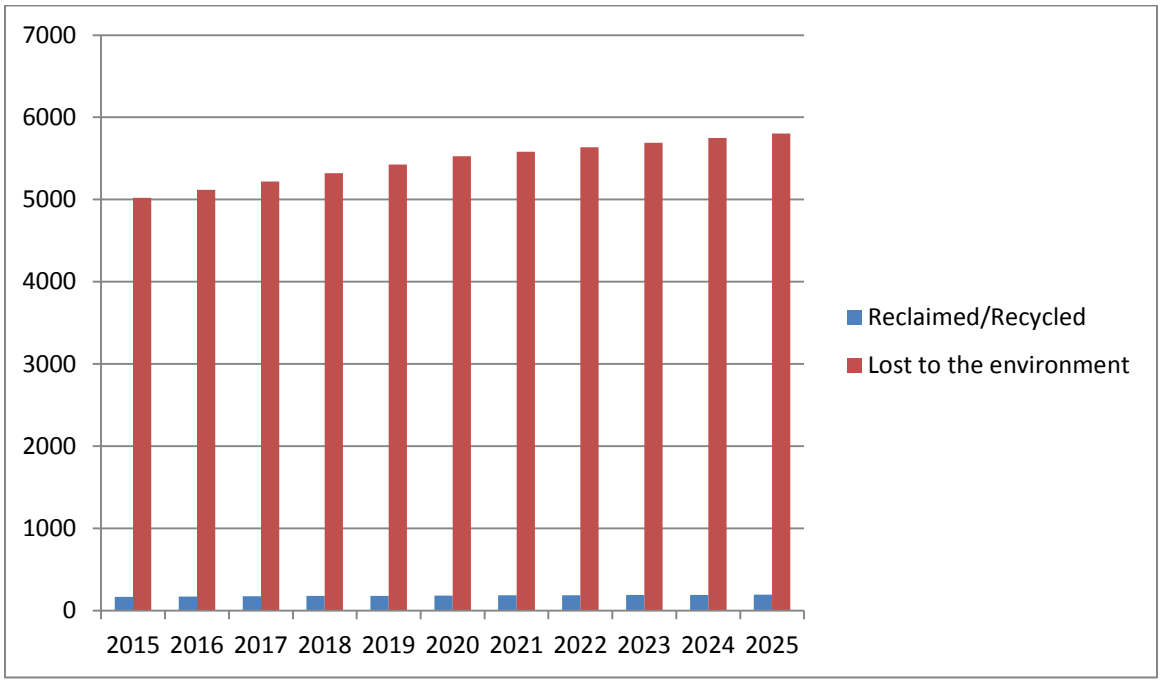
Figure 25. Projections for the uses of lead and non-lead ammunition in Canada by activity 2015-2025 (tonnes)



Note: Based on tonnes of projectiles

The following Figure 26 provides projections for the amount of lead from ammunition that is professionally reclaimed and recycled, and the amount expected to be lost to the environment. The amount of lead ammunition projectiles that are professionally recycled and reclaimed is based on the average annual quantity reclaimed and recycled from shooting ranges in Canada during the 2011-2015 period, which was ~3% of total lead uses in ammunition. It was assumed that 3% of total ammunition uses would continue to be reclaimed and recycled each year during 2016-2025. There was no indication from shooting ranges or recyclers that a significant increase in the reclamation/recycling rate was likely. The informal reuse of lead projectiles for re-loading and re-shooting is not included in the total recycled as the re-shot projectiles are ultimately expected to be lost to the environment. Lead ammunition used for hunting was assumed to be left in the field (e.g. after kills in gut piles, or lost/missed shots), or removed from the field and then disposed of later (e.g. removal of gut piles from the field limiting exposure of wildlife including scavengers). However, in both cases (i.e. left in field, or removed from field and disposed of later) it is assumed the lead is ultimately lost to the environment. Lead contained in game animal carcasses can then be butchered to remove meat containing larger lead fragments (this meat is expected to be discarded and not used for human consumption) and the remaining meat which may contain smaller lead fragments may then be consumed. Although the quantities associated with consuming lead-contaminated meat are expected to be extremely small compared to overall lead uses in ammunition, the human health impact on regular consumers of game meat could be significant.

Figure 26. Projections for total quantity of lead from ammunition professionally reclaimed/recycled and the amount lost to the environment in Canada 2015-2025 (tonnes)



The increased losses to the environment over the 2015-2025 period are due to the expected increased uses of lead ammunition in shooting sports coincident with increasing participation in the shooting sports, and assuming no notable increase in professional reclamation and recycling at ranges versus the level reported for 2011-2015. Further input from shooting ranges (e.g. following a CEPA section 71 survey) may reduce the estimated amounts lost to the environment if ranges are having lead professionally reclaimed to a greater degree than has been reported so far. In this BAU scenario the amount of lost to the environment per year due to the uses of lead ammunition increases from ~5000 tonnes in 2016 to ~5800 tonnes by 2025.

5.0 Review of Management Measures

In this section we review measures and management practices relevant to the management of lead in ammunition in Canada and other jurisdictions. In looking forward to how this review would be most useful in going forward, we have focused on what measures have been successfully applied as well as why some initiatives in the area have yet to be initiated, or have failed to be applied, despite scientific evidence of environmental and human health issues associated with the use of lead ammunition. Where relevant, an assessment of the measures used in other jurisdictions in the Canadian context is provided. It should be noted that historically regulatory restrictions on the use of lead ammunition have largely been focused on waterfowl, and hunting in or near wetlands, which is primarily associated with shotgun ammunition. Hence the discussion may seem weighted to this type of ammunition but that is simply because it is the type that has been subject to the most management measures internationally.

5.1 International

The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)[208] is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and Canada. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community in an effort to establish coordinated conservation and management of migratory waterbirds throughout their entire migratory range.[209] Canada, although a signatory to this Agreement, is not a ratified party.

The AEWA original Annex text when it came into force in 1999 (4.1.4) read that "Parties shall endeavour to phase out the use of lead shot for hunting in wetlands by the year 2000" and as a contribution to delivering the Aichi 2020 Biodiversity targets, it was agreed in 2012 that AEWA Parties should not only phase out the use of lead shot in wetlands but also evaluate the effectiveness of national measures already taken to this end, and understand and address barriers to implementation where measures are not effective (AEWA 2012).

Various countries have enacted laws requiring use of lead-free shot over wetlands, with the USA and Norway being the first to do so in 1991. Internationally, the regulation of lead ammunition use over terrestrial habitats is very limited.[210]

At the 11th Meeting of the Conference of the Parties to the UNEP Convention on Migratory Species (CMS) in November, 2014, Resolution 11.15 on Preventing Poisoning of Migratory Birds) and its Guidelines were adopted by the Parties. The guidelines include the recommendation to phase out all lead ammunition (gunshot and bullets) in all habitats (wetlands and terrestrial) within three years. The Resolution agrees that "it is for each Party to determine whether or how to implement the recommended actions, considering the extent and type of poisoning risk, whilst having regard to their international obligations and commitments, including those under the Convention".

[208] The Agreement area stretches from the northern reaches of Canada and the Russian Federation to the southernmost tip of Africa, covering 119 Range States from Europe, parts of Asia and Canada, the Middle East and Africa. Currently 75 countries and the European Union (EU) have become a Contracting Party to AEWA (as of 1 April 2016). http://www.unep-aewa.org/en/legalinstrument/aewa

[209] http://www.unep-aewa.org/en/legalinstrument/aewa

[210] Thomas 2015. Availability and use of lead-free shotgun and rifle cartridges in the UK, with reference to regulations in other jurisdictions. , In: Delahay, R.J. and C.J. Spray (Eds.), Proceedings of the Oxford Lead Symposium. Lead Ammunition: understanding the risks to human and environmental health, December 8, 2014. The University of Oxford, Edward Grey Institute.

5.2 Canada

Canada and the USA legislated the use of non-toxic shot under the Canada-USA 1916 Migratory Bird Treaty and the bilateral legislation for implementing the treaty. This treaty gives both Canada and the US federal authority to manage the exploitation of migratory birds (Thomas, 2003, Thomas and Guitart, 2010).

Beginning in 1989, the CWS, using its regulatory authority under the *Migratory Birds Convention Act*, and with Provincial agreement, established the first Canadian non-toxic shot zones in British Columbia, Manitoba, and Ontario in 1989 and 1990. At that time, CWS developed a set of criteria for assessing whether local lead exposure in waterfowl was sufficiently severe to require non-toxic shot regulations. This framework and its subsequent modifications were referred to as the "hot spot" approach to regulating the use of lead shot. The CWS criteria were accepted in 1990 by federal and provincial wildlife Ministers as an interim policy for managing the problems associated with the use of lead shot for waterfowl hunting. However, a national wing bone survey to determine the pattern of elevated lead exposure in hatch-year ducks in Canada reported a widespread geographic association between elevated bone lead concentrations and waterfowl hunting, rather than a few, local sites of high lead exposure (Scheuhammer and Dickson 1996). In addition, lead poisoning of Bald Eagles (*Haliaeetus leucocephalus*) in the USA and Canada had been linked to feeding on dead or wounded waterfowl containing lead shot (Pattee and Hennes 1983; Elliott et al. 1992). Scheuhammer and Norris (1995, 1996) indicated that a broader management approach than the 'hot spot' approach was required. In 1997, a national regulation came into effect prohibiting the use of lead shot for hunting migratory game birds within 200m of a watercourse anywhere in Canada (exempting upland migratory species—American Woodcock [*Scolopax minor*], Mourning Doves [*Zenaida macroura*], and Bandtailed Pigeons [*Columba fasciata*]) In 1999, this regulation was expanded when Canada adopted regulations requiring the use of non-toxic shot for all waterfowl hunting under *the Migratory Bird Conventions Act* (although upland migratory species were still exempt). After these non-toxic shot regulations were established in Canada, the incidence of elevated lead exposure in hatch year ducks declined dramatically, testifying to the effectiveness of the regulations and a generally high compliance by hunters.[211]The regulatory requirements for the use of non-toxic shot remain confined to waterfowl hunting. Upland game birds (e.g. quail, pheasants, grouse and partridges) do not migrate across national borders and hence fall under provincial jurisdiction (and in the US under state law).

Scheuhammer (2009) notes that bone lead concentrations in hatch-year ducks in Canada declined by 50%–90% (depending on species and location) after non-toxic shot regulations were established. Declines in bone-lead concentration were consistent with the results of a large anonymous hunter survey, which indicated a high level of reported compliance (>80%) with the nontoxic shot regulation among Canadian waterfowl hunters (Stevenson *et al.* 2005). In comparison, American Woodcock, an upland game species not affected by the non-toxic shot regulation, showed no decrease in mean bone-lead concentration in samples collected after the national regulation came into effect; and a majority (70%) of Canadian waterfowl hunters who also hunt upland game birds reported continued (legal) use of lead shot for upland game bird hunting (Stevenson *et al.* 2005). There are no provincial regulations prohibiting the use of lead for hunting non-migratory game species. However, concern for lead shot impacts on upland game birds and raptors continues to be warranted (Scheuhammer, 2009). For example, Ring-necked Pheasant (*Phasianus colchicus*) from a heavily hunted area in southern Ontario, Canada, had shot ingestion rates of up to 34% (Kreager *et al*. 2008). Studies such as these demonstrate that the ingestion of lead shot in upland game birds can be comparable to that documented for waterfowl prior to restrictions on the use of lead shot for waterfowl hunting (Scheuhammer, 2009).

There are also voluntary initiatives to encourage hunters in Canada to switch from lead to non-lead ammunition. For example, an ammunition exchange program in Nova Scotia provides a box of non-lead ammunition in

[211] Scheuhammer (2009. Historical perspective on the hazards of environmental lead from ammunition and fishing weights in Canada. In R. T. Watson, M. Fuller, M. Pokras, and W. G. Hunt (Eds.). Ingestion of Lead from Spent Ammunition: Implications for Wildlife and Humans. The Peregrine Fund, Boise, Idaho, USA. DOI 10.4080/ilsa.2009.0105 https://www.nps.gov/pinn/learn/nature/upload/Scheuhammer_2009_Hazards%20of%20Environmental%20Lead%20from%20Ammunition%20and%20Fishing%20Weights%20in%20Canada.pdf

exchange for a box of lead ammunition to encourage hunters to try the alternatives.[212] There has also been outreach to hunters to provide them with the scientific evidence linked lead ammunition use with raptor mortality and potential human health risks by Dr. Helene Van Doninck. These outreach efforts have been received by some groups with initial reluctance but, following presentation of the evidence, some hunters have been more receptive to trying non-lead ammunition. Offers to provide this presentation more widely to other associations of hunters across Canada have been met with refusals (i.e. by Canadian Wildlife Federation, Ontario Federation of Anglers and Hunters). [213] Individuals involved in these efforts are unable to quantify the impact in terms of numbers of hunters switching to non-lead in NS, but anecdotally these efforts appear to be having some notable success in terms of raising awareness and increasing the possibility that hunters will considering switching to non-lead alternatives.[214]

In terms of preventing or minimizing lead releases from shooting ranges there appears to be very little professional reclamation of lead at Canadian ranges (as described earlier in this report). Two larger ranges in Ontario used a professional reclamation company in the last 5 years.[215] In these cases, the upper layer of soil was removed and the lead separated for recycling. Two other smaller ranges in Canada indicated that a person came in with a 'lawnmower' type machine to collect lead from the impact area although they couldn't remember details as to the identity of the person or their company as it occurred >5 years ago. Note that the types of procedures and technologies used at ranges in the US are described in section 5.2 and the limitations associated with applying these in Canada are also provided in that section. Most ranges in Canada have informal reclamation/recycling procedures For example, they have regular 'clean-up' days done by members, with spent ammunition components (this is, mainly, discarded shotgun hulls, plastic wads, plus some lead bullet remnants from berms at pistol and rifle ranges) being collected and stored in pails until there is a sufficient amount to recycle. In these cases most ranges then indicated the lead was taken by a range member for recycling i.e. for that member to produce their own bullets for reloading although some of the lead may have been sent to 'the local metal recycling company'. However, when details of the recycling company were requested they could not be provided. It is important to note that relatively few ranges responded to requests for information. It is possible that Canadian ranges are doing more in terms of recycling but the resistance to providing information leaves us with little data in this area. Based on the responses received, data in the literature on lead contamination on ranges in Ontario, and expert input from Prof. Thomas we expect that very little reclamation and recycling of lead is occurring at ranges in Canada. The BCWF has been progressive in developing a BMP document for ranges (described earlier in this report) – this document is relatively new (developed in 2016) and is currently being refined – but could serve as a template for BMP for ranges across Canada.

5.3 USA

In 1991 the USA was one of the earliest nations to enact laws requiring the use of lead-free shot over wetlands. The USA–Canada 1916 Migratory Bird Treaty gives the US federal authority to manage exploitation of North American migratory birds. The bald eagle (*Heliaeetus leucocephalus*) is given additional federal protection in the USA, under its own *Bald and Golden Eagle Protection Act*, as well as in the *Endangered Species Act*, and the *National Environmental Policy Act*, in addition to protection under the *Migratory Bird Treaty Act* (Anderson, 1992; Thomas 2011). This complementary legislation enabled the USA to be the first nation to require use of non-toxic shot in 1991 (Thomas, 2011). In the US, waterfowl were identified, initially, as being most at risk from lead poisoning (Sanderson, 1992; Thomas 2011). It was also found that waterfowl killed or wounded by lead ammunition were often depredated by eagles, which ingested lead shot embedded in the tissues (Pattee and Hennes, 1983). Thus widespread secondary lead poisoning and mortality affected a species that was both an

[212] Halifax Wildlife Association in collaboration with the Habitat Conservation Fund, and other conservation groups: http://www.nsfah.ca/news/view.php?id=220 and pers. comm., Cobequid Wildlife Rehabilitation Centre
[213] Cobequid Wildlife Rehabilitation Centre, NS, Pers. comm. 2016
[214] Ibid
[215] MT2: http://www.mt2.com/firing-ranges/overview-of-services

emblem of the USA and a species then listed in the *US Endangered Species Act* (Anderson, 1992; Thomas, 2011). The prevalence of lead poisoning of protected avian species by direct or indirect ingestion of spent lead shot became (and still is) the most important driving factor directing US federal policy on lead shot reduction (Thomas, 2011).

The US federal government had legal powers to intervene under the above-mentioned acts to prevent the poisoning of eagles in addition to the poisoning of continental waterfowl (USFWS, 1986; Thomas 2011). Federal legislation applies to all member states of the USA, in which it is enforced. While the initial non-toxic shot regulations were applied nationally in 1991, to protect bald eagles and golden eagles (*Aquila chrysaetos*), the regulations' objective was the nation-wide hunting of waterfowl, as this was the actual source of the toxicological problem that could be managed (Thomas, 2011). An important aspect of US law enacting the treaty is that it gives the US government powers to regulate 'take', or harvesting, of birds by hunting (Thomas, 2011). This is a critical point in allowing the federal government to regulate a ban on the *use* of lead shot by hunters since *use* of shot is the basis of 'taking' (Thomas, 2011). The USA–Canada Migratory Bird Treaty does not deal directly with migratory birds' habitats because they fall largely under state (in US) and provincial (in Canada) jurisdiction.

Thomas (2011) notes that understanding jurisdictional authorities within the US is critical in understanding the regulation of lead products there [216], and is based on which animal species fall under federal or state control. Individual states have jurisdiction over the hunting of non-migratory game animals: federal jurisdiction applies to migratory birds and species protected under endangered species legislation (similar to the situation in Canada). Thus, non-toxic shot requirements for hunting waterfowl is federal law, non-toxic shot requirements for taking pheasants in South Dakota is state law, and the *Ridley-Tree Condor Preservation Act* of 2007 requiring non-toxic bullet use is California state law. To date, no single federal agency has the jurisdiction to regulate *use* of non-toxic shot, sinkers, and rifle bullets, collectively, across the entire United States because they all lack jurisdiction (Thomas 2011).

The US federal and various state agencies managing hunting have not agreed on how to manage lead exposure, while acknowledging the importance of the issue (Thomas, 2011). A large variation in the requirement for non-toxic shotgun ammunition exists in the US, as detailed by Thomas (2009). Not all migratory bird hunting requires use of non-toxic shot. Species such as mourning doves (*Zenaida macroura*) and woodcock (*Scolopax minor*) can still be hunted with lead shot ammunition, despite strong evidence that these species are subject to lead exposure from spent ammunition (Schultz *et al*. 2009; Thomas 2011). Twenty-six US states have regulations requiring the use of non-toxic shot for upland game hunting, although there is much variation among these states' regulations concerning their applications. Some apply to the hunting of federally regulated species (e.g., mourning doves) not addressed under federal law (Thomas 2011).

A group of non-governmental conservation organizations (American Bird Conservancy 2010) petitioned the US Environmental Protection Agency (EPA) in July 2010 to use provisions in the Toxic Substances Control Act (TSCA) to require use of non-toxic substitutes in the manufacture of shot, bullets, and lost sinkers. This petition contended that the US EPA could prohibit use of toxic lead in the manufacture of ammunition and sinkers, provided that non-toxic substitutes were available. In August 2010, the US EPA denied the petition, contending that the agency lacked the authority to regulate ammunition, nor was about to seek it (EPA 2010). This is due to some of the legal limitations of TSCA in this context. In this regard, it is very important to note that ammunition and firearms are exempt from TSCA's regulatory authorities. In addition, from a historical perspective, it has been very difficult for US EPA to take action on certain chemicals under TSCA due to the onerous legal requirements of the Act[217]. In contrast, the Canadian Federal Government does have jurisdiction to restrict the manufacturing, import, sale and use of lead in products (including ammunition products) under the authority of CEPA.

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[216] Thomas 2011. Conflicts in lead ammunition and sinker regulation: Considerations for US National Parks. The George Wright Forum.

[217] In particular the requirement that US EPA prove that the risk management measure proposed was the 'least burdensome' - a provision of section 6 of TSCA which US EPA found an insurmountable obstacle in the risk management of toxic chemicals, and was a requirement of TSCA from 1976 until the Act was finally revised in 2016. The 'least burdensome' provision was deleted in 2016.

Analysis by Thomas (2011) indicates that a number of reasons beyond the jurisdictional issue in the US may also help to explain the absence of concerted action by game agencies and the slow rate of transition to non-toxic materials. Thomas (2011) notes that not all wildlife professionals see the issue of lead exposure having such importance as to warrant wide-scale transitions to non-toxic shot, bullets and sinkers. Other professionals fear that regulated bans on all lead products would drive hunters and anglers from their sports, resulting in a decline in dedicated funding (e.g., Pittman-Roberts funds) to state and federal agencies, and with that a reduced ability to manage (Thomas, 2011). Note that at the provincial level in Canada, similar issues and conflicts exist. For example, provincial natural resources ministries in Canada gain a significant portion of their revenues from hunting and fishing licence fees. All agencies are obliged to serve the public, comprising of those who favour species preservation or the consumptive use of wildlife, as well as the interests of wildlife species. Wildlife agencies are also self-interest groups (Thomas 2011). These conflicts are relevant for both the US and Canada.

Thomas (2011) notes that while sporting organizations purport to represent all hunters, individuals often fall into discrete camps according to their principal sporting interests. There are waterfowl hunters, upland game hunters and big game hunters, and clay target shooters each with their own special interests in the lead exposure issue and what regulation would mean to their sport. Most of the sporting public and their representative organizations in the US and other nations have resisted the adoption of non-toxic products.[218]

Despite the challenges involved, some US states have been successful in restricting the uses of lead ammunition beyond the ban on lead uses in waterfowl hunting (see table 45 below). The most extensive action has been undertaken in California (see section 5.3.1).

Note that in all cases, restrictions on the uses of lead ammunition were based on the ingestion of lead shot by birds and the resultant toxicity, including resulting in higher mortality rates in the population. Many states ban lead ammunition only at specific sites (e.g. specified wildlife management areas). Some US State wildlife codes currently require that lead ammunition can only be banned at specific sites where there are documented cases of lead poisoning at the specific site and all alternative methods of alleviating lead poisoning (such as dewatering, flooding, or tillage) have been determined to be unsuccessful in preventing lead poisoning, and after statewide public hearings have then been held[219]. These types of onerous requirements greatly restrict the ability of some US States to apply wider-scale restrictions or State-wide bans. As a recent example, Illinois Senate Bill 1985 proposes to remove these onerous requirements from their Wildlife Code and to ban lead ammunition from State Parks and protected natural areas - and this bill was passed by the Senate Environment and Conservation Committee on March 16, 2017 and is scheduled to be debated in the senate on March 28, 2017. [220] SB 1985 is being strongly opposed by the NRA.[221]

[218] Thomas 2011. Conflicts in lead ammunition and sinker regulation: Considerations for US National Parks
[219] E.g. see section 2.18.1 of the Wildlife Code from the State of Illinois
[220] Senate Bill 1985 (Illinois) March 2017; http://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=052000050K2.18-1
[221] NRA:Illinois: Committee passes lead ammunition ban: https://www.nraila.org/articles/20170316/illinois-committee-passes-lead-ammunition-ban

Table 45. Summary of Lead Ammunition Measures in US States

State	Description of Measure	Details
Alabama	Nothing in addition to federal regulations	Federal only, enacted 1991
Alaska	In addition to federal regulations, non-toxic shot is required in specified wildlife areas when taking game under the provision of a hunting license with a shotgun. In Alaska Hunting Regulations.	Restriction stated as "In Unit 18, taking game under provisions of either a hunting or trapping license using a shotgun or using loose shot in a muzzleloading firearm is ONLY ALLOWED using nontoxic shot size T (.20" diameter) or smaller, and hunters may not be in immediate possession of lead shot. Lead shot size T (.20" diameter) or smaller is prohibited."[222] Limited to specified wildlife management areas.
Arizona	Non-lead ammunition is encouraged when hunting within the California Condor's range in Arizona (Game Management Units 12A, 12B, 9, 10, 13A, 13B)[223].	Voluntary measures, measures restricted to specified game management areas, introduced starting in 2005, evidence of reduced lead exposure following introduction
Arkansas	Migratory birds not considered waterfowl (doves, rails, woodcock, snipe, moorhens, gallinules) can be hunted with size T and smaller non-toxic shot or size BB and smaller lead shot.	Voluntary
California	Non-toxic ammunition required in the eight-county historic range of the California condor. There will be a complete ban on the use of lead ammunition for any hunting purposes anywhere in the state by July 1, 2019.	Measures introduced starting in 2008 with phase-in to full state-wide ban by 2019
Colorado	Non-toxic shot required in the Alamosa/Monte Vista/Baca National Wildlife Refuge Complex and when hunting ducks, geese or coots.	Measures restricted to wildlife refuge area
Delaware	During the month of September, all hunters must use non-toxic shot when dove hunting in State Wildlife Areas.	Measures restricted to specified wildlife areas.[224]
Illinois	Non-toxic shot required for dove hunting on some public lands. On March 16, 2017, the Senate Environment and Conservation Committee passed Senate Bill 1985 by a 5-3 vote. SB 1985 now heads to the Senate floor where it will be debated on 28 March 2017.	Existing measures restricted to specified wildlife areas. SB 1985 would amend the Wildlife Code. Provides that it shall be unlawful to use lead ammunition to take wildlife in State parks or natural areas. Defines "lead ammunition" as a projectile containing

[222] 2016-2017 Alaska Hunting Regulations: https://www.adfg.alaska.gov/static/regulations/wildliferegulations/pdfs/gmu18.pdf
[223] Arizona Game and Fish Department: http://www.azgfd.gov/w_c/california_condor_lead.shtml
[224] Delaware hunting regulations: http://www.eregulations.com/delaware/hunting/migratory-bird/

State	Description of Measure	Details
		one or more percent lead by weight. Makes conforming changes effective immediately.[225]
Iowa	Non-toxic shot required for all game in wildlife management areas except for deer and turkeys. No person may take ducks, geese (including brant), rails, snipe, or coots while possessing shot (either in shotshells or as loose shot for muzzleloading) other than approved non-toxic shot. Iowa prohibits any target shooters using shotguns with lead shot that discharges over water. (See IOWA ADMIN. CODE 571-51.3(481A)).	Covers all game and all wildlife management areas (deer and turkey hunting exempt) The Iowa Department of Natural Resources offers education programs on alternatives to lead ammunition.
Kansas	At least 17 state wildlife areas and refuges require non-toxic shotgun load for upland game birds such as pheasant, grouse and quail and other small game.	Covers all game in specified wildlife management areas Nontoxic shot must be used for all species when hunting on certain areas owned or managed by the department. (See KAN. ADMIN. REGS. § 115-8-1 and KAN. ADMIN. REGS. § 115-8-3). Also, Nontoxic shot or bullets must be used when conducting operations under a nuisance bird control permit (Proposed for adoption on August 11, 2011 at KDWP public hearing) (See KAN. ADMIN. REGS. § 115-16-3).
Kentucky	Non-toxic ammunition required for doves in 13 wildlife management areas and national wildlife refuges.	Covers only doves in specified wildlife management areas
Louisiana	Non-toxic ammunition required for doves at Pointe-aux-Chenes Wildlife Management Area.	Covers only doves in specified wildlife management areas
Maine	Non-toxic shot when hunting upland game other than deer and turkey. This regulation applies in national wildlife refuges, wildlife management areas and refuges, and for migratory game birds snipe and/or rail on all state and private lands. (09 137 CMR 4.02(G))[226]	Covers upland game in specified wildlife management areas (deer and turkey hunting exempt)
Maryland	Non-toxic shot is required for hunting rail and snipe.	Covers only certain species
Minnesota	In addition to federal regulations, non-toxic shot must be used for sandhill cranes.	Measures minimally expand on federal law

[225] Illinois General Assembly Bill Status of SB 1985: http://www.ilga.gov/legislation/BillStatus.asp?DocNum=1985&GAID=14&DocTypeID=SB&LegId=105382&SessionID=91&GA=100

[226] Maine Department of Inland Fisheries and Wildlife: http://maine.gov/ifw/hunting-trapping/

State	Description of Measure	Details
Missouri	Non-toxic shot for shotguns required in 21 conservation areas.	Measures restricted to specified wildlife management areas
Montana	Nothing additional to federal law	Federal only: introduced 1991
Nebraska	In addition to federal regulations, non-toxic shot is required in some state wildlife management areas.	Measures restricted to specified wildlife management areas
New Jersey	In addition to federal regulations, non-toxic shot is required for rail, snipe, or moorhens on all state and private lands	Measures minimally expand on federal law
Nevada	Non-toxic shot required for coots, gallinules and snipe.	Measures minimally expand on federal law
New Mexico	In addition to federal regulations, non-toxic shot is required for common moorhen, sora, Virginia rail and snipe Non-toxic shot is also required on all State Game Commission owned or managed areas when hunting with a shotgun (slugs excluded).	Measures restricted to few additional species and specified wildlife management areas
New York	In addition to federal regulations, non-toxic shot is required for snipe, rails or gallinules.	Measures minimally expand on federal law
North Carolina	In addition to federal regulations, non-toxic shot required for the taking of captive-reared mallards on shooting preserves, in field trials and during bona fide dog training activities.	Measures minimally expand on federal law
North Dakota	In addition to federal regulations, non-toxic shot is required for sandhill cranes and snipe.	Measures minimally expand on federal law
Ohio	In addition to federal regulations, non-toxic shot is required when hunting with a shotgun in Metzger Marsh, Mallard Club, Pipe Creek, Magee Marsh, Toussaint, and Little Portage wildlife areas.	Measures restricted to specified wildlife management areas
Oklahoma	In addition to federal regulations, non-toxic shot must be used while hunting Foss State Park and, unless otherwise noted, non-toxic shot is required on all state wetland development units and state waterfowl refuges.	Measures restricted to specified wildlife management areas, state parks
Oregon	In addition to federal regulations, non-toxic shot is required for snipe and on some state refuges, state wildlife areas and regulated hunt area.	Measures restricted to certain species only in specified wildlife management areas
South Dakota	In addition to federal regulations, non-toxic shot is required for hunting snipe and muskrat (if shooting with shotgun), and all state game production areas, lake and fishing access areas, state park system areas, and U.S. Army Corps of Engineers lands and U.S. Bureau of Reclamation Wildlife Production Areas. Target shooting with lead shot is also	Combination of mandatory and voluntary measures (e.g. 'recommends' non-lead)

State	Description of Measure	Details
	prohibited on the state and federal lands listed above. Essentially all upland game hunting with shotguns must use lead-free ammunition on both private and state owned lands (introduced 1998). GFP[227] encourages hunters to use non-toxic shot for all hunting, even in areas where its use is not required.	
Tennessee	Nothing in addition to federal laws	Only federal: since 1991
Texas	Nothing in addition to federal laws	Only federal: since 1991
Utah	The use of non-lead ammunition is encouraged in the Zion hunting unit, a secondary territory of the California Condor. Non-toxic ammunition required for sandhill cranes and on some state wildlife and waterfowl management areas.	Combination of mandatory and voluntary measures (e.g. 'recommends' non-lead in range of California condor)
Virginia	In addition to federal regulations, non-toxic shot is required for snipe, rail, moorhens, and gallinules. VDGIF also recommends using non-lead rifle ammunition for big game hunting.	Combination of mandatory and voluntary measures (e.g. 'recommends' non-lead for big game hunting')
Washington	In addition to federal regulations, non-toxic shot is required for snipe and while hunting in many state wildlife areas and on all areas where pheasants are released.[228] Measures introduced Jan 1, 2011.	Nontoxic shot is now required for bird hunting (pheasant, quail, chukar, gray partridge, mourning doves and band-tailed pigeons) on all pheasant release areas, statewide. It is unlawful to possess shot (either in shotshells or as loose shot for muzzleloading), other than nontoxic shot, when hunting for upland game birds (pheasant, quail, chukar, and gray partridge), mourning doves, band-tailed pigeons, on all areas where pheasants are released by WDFW. Violations bring a mandatory $1,000 fine and loss of small game hunting privileges for two years.
Wisconsin	In addition to federal regulations, non-toxic shot is required for snipe, rails and moorhen plus doves on all Department of Natural Resources-managed lands. Non-toxic shot is also required while turkey hunting on National Wildlife Refuges and Federal Waterfowl Production Areas. The DNR recommends using non-toxic shot when dove hunting on private land and when hunting woodcock. The DNR also recommends considering the use of non-lead rifle ammunition for deer hunting.	Combination of mandatory and voluntary measures (e.g. DNR 'recommends' non-lead for deer hunting').

[227] South Dakota Game Fish and Parks: http://gfp.sd.gov/hunting/
[228] Washington Department of Fish and Wildlife: http://wdfw.wa.gov/hunting/nontoxic_shot/

State	Description of Measure	Details
Wyoming	In addition to federal regulations, non-toxic shot is required when hunting game birds or small game with a shotgun on Springer and Table Mountain Wildlife Habitat Management areas. Non-lead ammunition is required for hunting elk in Grand Teton National Park. The use of non-lead rifle ammunition is encouraged when hunting elk and bison on the National Elk Refuge.	Combination of mandatory and voluntary measures (e.g. DNR 'recommends' non-lead for elk and bison hunting in wildlife refuge).

Some further details are provided below for several states i.e. (1) Arizona, which has undertaken a voluntary approach which appears to have been effective, (2) Washington, which provides background to their management measures and addresses some concerns of hunters regarding non-toxic ammunition, and (3) California (see section 5.3.1) with the most extensive management measures of any US state.

Arizona: The Arizona Game and Fish Department provide the following summary of their voluntary efforts to reduce the use of lead ammunition: 'Since 2005, as part of an effort to reduce lead exposure in condors, the Arizona Game and Fish Department has provided free non-lead ammunition to big game hunters in Units 12A, 12B, 13A, and 13B (the areas condors frequent most during the hunting season). The department also instituted a gut pile raffle program where hunters shooting lead-based ammunition in these units remove their gut piles from the field for proper disposal. Hunters responded with 80 to 90 percent voluntarily using non-lead ammo or removing their gut pile to benefit condors since 2007. Thanks to the efforts of these hunters, the amount of lead available to condors has been reduced in Arizona. According to post-hunt survey results, 93 percent of hunters who used the non-lead ammunition said it performed as well as or better than lead bullets. In addition, 72 percent of all hunters said they would recommend the 100 percent copper bullets to other hunters.

The department's free non-lead ammunition program will continue as long as funding permits and is supported by the Heritage Fund (state lottery dollars), Wildlife Conservation Fund (state gaming revenue) and the Federal Aid funds (Pittman-Robertson act).

Several sportsmen's groups and agencies joined the effort to help condors. A Condor Conservation Coalition was formed to promote voluntary lead reduction efforts within condor range, including the use of non-lead ammunition. Current local coalition members include the Arizona Deer Association, Arizona Antelope Foundation, Arizona Desert Bighorn Sheep Society, and Arizona Chapter of the National Wild Turkey Federation.'[229]

It is interesting to note that this program removes the issue of increased costs for non-lead by providing free ammunition, and has been successful in resulting in voluntary switching. Note also that California used a similar approach (see section 5.3.1)

Washington: Washington Department of Fish and Wildlife (WDFW) provide the following background to their restrictions on lead shot on their website:[230]

"Through monitoring, problems with lead shot have been discovered in some western Washington pheasant-release sites that also are waterfowl feeding areas. For example, soil sampling at Skagit Wildlife Area yielded an estimated 6.8 tons of lead. Sampling lead pellet densities in soil and wildlife tissues is considered to be the best way to identify problem areas, but these methods are labor intensive, expensive and sometimes difficult to interpret. Not all sites present potential problems. However, all release sites were converted to nontoxic shot use based on a high potential for ingestion of lead by wildlife, due to the higher densities of hunters depositing lead shot on these areas.

[229] Arizona Game and Fish Department: http://www.azgfd.gov/w_c/california_condor_lead.shtml
[230] http://wdfw.wa.gov/hunting/nontoxic_shot/

Hunter concerns about nontoxic shot. *Hunters have voiced concerns about cost, effectiveness and shotgun barrel damage in using nontoxic shot. This is what we know about these areas of concern:*

- ***Cost:*** *Alternatives to lead shot are more expensive -- particularly newer alternatives, which can cost more than $2 a shell. However, steel shot prices have declined and are approaching those of lead shot. Prices of newer alternatives are expected to decline as new types become more widely available.*
- ***Steel performance:*** *In numerous shooting tests, wounding loss from the use of steel shot has been scientifically shown to be no different from that of lead. Poor performance of steel often is related to mismatched load/choke combinations and exceeding the effective range of loads. Several of the new alternatives have ballistics properties similar to lead, helping to reduce concerns about effectiveness.*
- ***Barrel damage:*** *Fears about choke damage from steel non-toxic shot have not been substantiated for the vast majority of shotguns. Hunters should check with shotgun manufacturers to be certain."*[231]

The WDFW then provides a summary of the scientific evidence for lead poisoning in upland birds including abstracts for the following studies:

- **Lead Pellet Ingestion and Liver-Lead Concentrations in Upland Game Birds from Southern Ontario, Canada**
- **Evidence of Lead Shot Problems for Wildlife, the Environment, and Human Health -- Implications for Minnesota**
- **Ingested shot and tissue lead concentrations in mourning doves** [232]

5.3.1 California

The California Department of Fish and Game (CDFW) introduced measures for lead ammunition effective July 1, 2008 (AB 821), these modified the methods of take to prohibit the use of projectiles containing lead when hunting big game and non-game species in an area designated as the California condor (*Gymnogyps californianus*) range[233].

The bill AB 821 enacted the *Ridley-Tree Condor Preservation Act*[234] to require the use of non-lead centerfire rifle and pistol ammunition when taking big game and coyote within specified areas. In practice, the regulations banned the use of lead ammunition for hunting of deer, wild pig, elk, black bear, pronghorn antelope, coyote and ground squirrel within the range of the federal and state endangered California condor. The purpose of the regulation change was to reduce the potential for lead poisoning of condors by eliminating lead that could be contained as fragments within carcasses of hunted big game and non-game species. Through intended protection of the Condor, it was recognised that the regulations may also work to reduce lead exposure in other scavenger birds and mammal species.[235] The act required the California Fish and Game Commission to establish, by regulation, by July 1, 2008, a public process to certify centerfire rifle and pistol ammunition as non-

[231] Ibid
[232] Ibid
[233] California Department of Fish and Wildlife: https://www.wildlife.ca.gov/hunting/nonlead-ammunition
[234] Assembly Bill 821: Ridley-Tree Condor Preservation Act: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=82802

[235] California Department of Fish and Wildlife; Report on levels of lead found in California Condors during 2009: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=21622&inline=1

lead ammunition, and to define non-lead ammunition by regulation. The act also required the commission, to the extent funding is available, to provide hunters within these areas with non-lead ammunition at no or reduced charge[236] through a coupon program. Under the act, a person who violates those requirements would be guilty of an infraction punishable by a $500 fine for the first offense.

A follow-up report by the CDFW published in 2013 found that although the population of condors in the wild continues to increase the level of mortality in the population continued to be a problem.[237] CDFW concluded that the largest single threat has been and continues to be exposure to lead, causing a high number of mortalities and an unknown, but high level of lead morbidity. The continued use of lead ammunition, not banned under AB 821, was identified as a key contributor to this continued problem.[238]

In October 2013, Assembly Bill 711 was signed into law requiring the use of non- lead ammunition when taking any wildlife with a firearm in California. This law requires the Commission to adopt by July 1, 2015, regulations that phase-in the statute's requirements, but it must be fully implemented by July 1, 2019. The phased-in approach is as follows:

Phase 1 – Effective July 1, 2015, non-lead ammunition will be required when taking Nelson bighorn sheep and all wildlife on CDFW wildlife areas and ecological reserves.

Phase 2 – Effective July 1, 2016, non-lead shot will be required when taking upland game birds with a shotgun, except for dove, quail, snipe, and any game birds taken on licensed game bird clubs. In addition, nonlead shot will be required when using a shotgun to take resident small game mammals, furbearing mammals, nongame mammals, nongame birds, and any wildlife for depredation purposes.

Phase 3 – Effective July 1, 2019, non-lead ammunition will be required when taking any wildlife with a firearm anywhere in California." [239]

CDFW conducted extensive public outreach during 2014 and proposed regulations that phase-in the non-lead requirement. This outreach effort included question and answer sessions at sportsmen's shows, meetings with hunting organizations and a series of eight public workshops throughout the state. CDFW then presented draft regulations, as modified by public input from these workshops, to the Fish and Game Commission.

In April 2015, the Fish and Game Commission adopted CDFW's proposed regulations, which will implement the non-lead requirement in the aforementioned three phases:

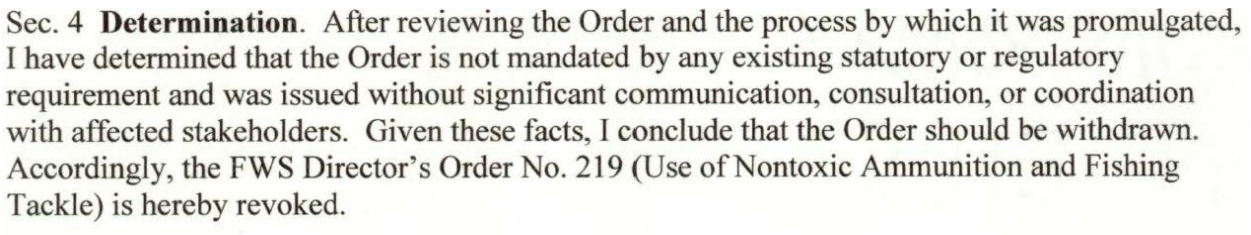
Outreach efforts include updates to the department website, providing flyers to CDFW hunting license agents and other ammunition retailers for posting in their businesses, CDFW social media, news releases, posting of information at areas where non-lead ammunition is required and sending reminder emails to hunting and conservation groups. Public outreach will continue throughout the implementation of AB 711.

California is the only state to have passed legislation requiring the use of lead-free rifle ammunition for hunting. The passage of these regulations is predicated on the known effectiveness of lead substitutes and their growing availability as makers increase their production towards 2019.

In addition, one of the last actions of President Obama before leaving office was to issue an Executive Order (No.219) on Jan 19, 2017 that banned the use of lead ammunition and sinkers on federal lands. The Order required 'the use of nontoxic ammunition and fishing tackle to the fullest extent practicable for all activities on service lands, waters and facilities by January 2022, except as needed for law enforcement or health and safety issues, as provided for in policy'[240] The Order was effective immediately and was written to remain in effect until incorporated into the Fish and Wildlife Service Manual, or until it is amended, superseded or revoked. The

[236] Similar approach to Washington State
[237] CDFW 2013: California condor recovery program: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=75883&inline=1
[238] Ibid
[239] https://www.wildlife.ca.gov/hunting/nonlead-ammunition
[240] Fish and Wildlife Service: www.fws.gov/policy/do219.html (Consulted October 2016)

incoming administration immediately placed a hold on all federal government programs related to the environment hence any action on the EO 219 was suspended. Subsequently, on March 2nd 2017 and on his first full day in office, Trump's Interior Secretary Ryan Zinke issued an order revoking EO219 reversing the position of the U.S. Fish and Wildlife Service under President Obama that called for a phase-out of the use of toxic lead on federal lands by 2022.[241] Zinke provided the following brief justification for the revocation of EO219:



Sec. 4 **Determination**. After reviewing the Order and the process by which it was promulgated, I have determined that the Order is not mandated by any existing statutory or regulatory requirement and was issued without significant communication, consultation, or coordination with affected stakeholders. Given these facts, I conclude that the Order should be withdrawn. Accordingly, the FWS Director's Order No. 219 (Use of Nontoxic Ammunition and Fishing Tackle) is hereby revoked.

Source: Extract of Order Number 3346, The Secretary of the Interior, Washington DC, USA. Dated March 2nd, 2017

Zinke's revocation was applauded by the National Rifle Association with Chris Cox of the NRA stating "On behalf of the five million members of the NRA and tens of millions of American sportsmen, we thank Secretary Zinke for eliminating this arbitrary attack on our hunting heritage,"[242] Note that NRA routinely sues any government agency that attempts to control the uses of lead ammunition stating that "these lead ammunition efforts are crucial to preserving Second Amendment rights through the availability of ammunition. NRA and its lawyers are constantly monitoring and responding to attacks on the use traditional ammunition."[243]

In addition to regulatory measures and voluntary recommendations from Federal and State governments other procedures used in the US act to manage releases of lead at locations allowing the use of ammunition. In particular, the reclamation and recycling of lead from shooting ranges in the US appears to be much more extensive than in Canada. The US has much larger shooting ranges than exist in Canada, many are based on large expanses of flat land and impact areas can be covered with sand[244]. These features make it easy and efficient to regularly collect the spent ammunition for recycling. The large densities of lead in large ranges also make the recovery of lead from ranges highly economical. These combinations of conditions just do not exist at shooting ranges in Canada. The large US ranges regularly use recovery machines (that are similar to a cross between a vacuum cleaner and lawnmower) to efficiently sift through the sandy upper layer of the impact area recovering the spent ammunition. Because the ranges are large and have many participants, a large amount of lead is deposited regularly, a quantity large enough to be valuable, and hence there is incentive to reclaim and recycle on a frequent basis. The upper layer of soil at outdoor ranges can also be removed and processed separating the lead for recovery. For example, MT2 a US company that specializes in shooting range reclamation has conducted 1,200 projects in the US and recovered >5,000 tonnes of lead since 2000[245]. Some large ranges in the US operate their own in-house reclamation machines. Most ranges in Canada are small compared to US ranges, and many are situated in locations that contain varied terrains including wetlands, water bodies, trees and/or rocky areas making reclamation of this type much less efficient or economical than in the US[246]. US companies like MT2 have interest in reclaiming lead from larger ranges in Canada but have received very little interest from Canadian ranges in recent years. For small volunteer-run ranges, particularly those with features that make reclamation difficult, the costs of reclamation can be prohibitive. The type of large

[241] Order Number 3346 Revocation of the United States Fish and Wildlife Service Director's Order No. 219 (Use of nontoxic ammunition and fishing tackle). March 2nd, 2017. Signed by the Secretary of the Interior.
[242] https://www.nraila.org/articles/20170302/the-nra-applauds-secretary-zinkes-protection-of-traditional-ammunition
[243] See NRA: https://www.nraila.org/articles/20150501/nra-crpa-california-legal-affairs-report and The Guardian 16 March 2017: 'Bald eagles: scientists decry overturn of ban that would save American symbol': https://www.theguardian.com/environment/2017/mar/16/us-bald-eagles-lead-poisoning-ammunition
[244] Prof. V. Thomas pers. comm. 2016
[245] MT2: http://www.mt2.com/firing-ranges/overview-of-services
[246] Ibid

scale and efficient reclamation of lead conducted at large US ranges is simply not practical at the vast majority of ranges in Canada.

5.4 Europe

European Participation in Multilateral Conservation Instruments: The Birds Directive of the EEC (CEC, 1979) has several of the same conservation goals as the Migratory Bird Treaty of North America. As this treaty applies to all states and provinces within North America, the Birds Directive applies equally to all EU nations. However, the directive lacks the explicit powers of the Canadian and US legislation to remove lead shot in federally regulated pursuits (Thomas, 2011). There is much variation in regulative reform across Europe in regards to the EEC Birds Directive. By contrast, the USA and Canada are both full parties to the Migratory Bird Treaty and are bound legally by it (Thomas, 2011). Article 1 of the directive 'covers the protection, management and control of these species and lays down rules for their exploitation'. Article 1 also applies 'to birds …and habitats'. Article 4(4) of the directive refers to member states taking 'appropriate steps to avoid pollution or deterioration of habitats' of (bird) species requiring special conservation measures. It could be construed that the general terms expressed in Articles 1 and 4 are consistent with removing lead shot from use, as in the exploitation (or take by hunters) and the prevention of accumulation of a toxic pollutant in birds' habitats. However, this is too narrow of an interpretation of these articles, which were included in the original directive of 1979, when avian lead poisoning had yet to become a major conservation issue. Article 14 of the directive 'allows member states to introduce stricter protective measures than those provided for under this Directive', and this is what happened when individual countries (such as Denmark, The Netherlands, Spain and the UK) introduced their own national or regional regulations concerning lead shot and sinker use (Beintema, 2001), in the absence of provisions at the EU level (Thomas 2011).

Thomas and Guitart (2005) examined the roles of large international conservation conventions in promoting the welfare of birds by promoting countries' adoption of non-toxic products. They noted that the EU is a party to the Conservation of African–Eurasian Migratory Waterbirds (AEWA) of the United Nations, and so is obliged to consider, and possibly enact, its principal recommendations. However, the only action on a lead shot/sinker ban has come from individual nations of the EU and not the Community. Individual nations that have regulated against the use of lead shot/sinkers have either created new legislation or amended their existing legislation to make this happen. For the EU, the problem appears to be not having the appropriate legislative basis for action combined with a political climate that resists such a regulatory change (Thomas, 2011).

As in the US, lead poisoning of eagles also occurs in Europe (Pain *et al.*, 2005), but these species lack the dedicated legislation of eagles in the US (Thomas, 2010). Another factor confounding regulatory change is that not all European nations sharing common populations of migratory birds are members of the EU - this is the value of the AEWA, in transcending both EU and non-EU nations (Thomas 2010). Norway has shown greater leadership than most EU nations in banning lead shot use for certain forms of hunting since 1991, with an additional ban on hunting outside of wetlands with lead introduced in Norway in 2005 (Beintema, 2001; Thomas 2011). However, the Norwegian Parliament voted to repeal the 2005 ban on lead shot for hunting outside of wetlands in February 2015. This change followed a decade of lobbing by the Norwegian Association of Hunters and Anglers (*Jegernes Interesseorganisasjon (JI)*) and Norway's Weapons Council who have been credited with causing this policy change.[247] The arguments used by JI included that the ban lacked a solid evidential basis and that the use of alternative ammunition posed animal welfare risks. They argued that non-lead ammunition does not kill as cleanly or as efficiently as lead, and therefore causes unnecessary suffering. JL also maintained that the potential adverse effects of such substitute materials on health and the environment have not been studied in sufficient detail.[248] These are arguments that have been used by hunting/shooting lobby groups around the world to oppose bans and, as discussed throughout this report, these arguments are not supported by the current scientific information. In understanding the repeal in 2015 it is important to realize that

[247] https://ssaa.org.au/news-resources/research-archive/lead-ammo-ban-lifted-in-norway/
[248] http://www.shootinguk.co.uk/news/lead_shot_ban_vote_norway-42462#4TDOEwS85ZTZJq8W.99

the political leadership in Norway changed at the end of 2013.[249] Following this political change, JI received statements of political support from Norway's Conservative Party, Progress Party, and Christian Democratic Party amongst others which indicated they could now achieve a parliamentary majority. Hence, in 2015, an overwhelming majority of MPs (79 against 16) supported the bill, disregarding scientific evidence on health and environmental risks from lead-based ammunition.[250] The Norwegian Association for Hunters and Anglers (NJFF 2015) described the reintroduction of lead shot for hunting as a "victory," and the Association of European Manufacturers of Sporting Ammunition (AFEMS 2015) called the decision a "great success." When considering this recent reversal in Norway, the following observations by Arnemo *et al* (2016) should be borne in mind:

"*In 'Merchants of Doubt', Oreskes and Conway (2010) showed how denial of scientific evidence has been a strategy used by those with vested interests in important health and environmental issues such as climate change, tobacco smoking, ozone layer thinning, acid rain, and DDT. The ongoing discussion on the use of lead-based ammunition parallels the debates covered by Oreskes and Conway. Thus, extensive scientific evidence is disputed or rejected, lead substitutes developed by the ammunition industries are deemed inadequate or too expensive, and proposed bans on lead ammunition are often viewed as anti-hunting. Less than 5% of the Europeans are sport hunters. Their political impact, however, is disproportionately large. Hunters are well-organized at national and international levels, and are represented effectively by industry and wealthy politically influential groups."*

The ban in Norway was not repealed because of a change in scientific evidence. It was repealed because the political climate changed to one that was more sympathetic to the lobbying efforts of the hunting associations that opposed it.

As Arnemo *et al* (2016) recently observed:

"*Despite overwhelming scientific evidence and increasing policy imperatives, nationally regulated bans on the use of lead shotgun and rifle ammunition are few. North American and European arms industries have developed non-toxic shot and bullets that are as effective and comparably priced as their lead counterparts (Thomas 2015). Our understanding of the deleterious impacts of this form of lead exposure on wildlife and humans will change little with further scientific research, no more evidence is required. The same rationales that were used to remove lead from gasoline, paints, and household items should be applied to lead-based hunting ammunition, nationally and internationally. This is now a socio-political issue.*"

Evaluations of European Policy and Law and Criteria Adopted by Agencies: The European Parliament has allowed individual parties to determine their policy on the use of lead ammunition, despite the EU being a party to the African–Eurasian Waterbird Agreement (AEWA) of the Bonn Convention. Under Section 4.1.4 of the Action Plan contained in the agreement, nations are only 'encouraged', not required, to phase out the use of lead shot by 2000.

Article 14 of the Bern Convention also called for a ban on the use of lead shot, and introduced recommendations to ensure its success (Thomas and Owen, 1996; Thomas and Guitart, 2005). The recommendations were adopted in 1991, but no provisions for enforcement were developed, and no country was obliged to adopt them (Thomas, 2010). The Organization for Economic Cooperation and Development

[249] The outgoing Government led by Prime Minister Jens Stoltenberg was a coalition between the Labour Party, the Socialist Left Party and the Centre Party. It has been in power since 2005. The change of government is the result of the September 9, 2013 election in which the Conservative Party, the Progress Party, the Liberal Party and the Christian Democratic Party (right wing coalition: http://www.bbc.com/news/world-europe-17743896) together won a majority in the Storting (Norwegian parliament). http://www.norway.org/News_and_events/Embassy/Norways-new-Government-/#.WL2cavnsKUk

[250] Arnemo et al., 2016. Health and Environmental Risks from Lead-based Ammunition: Science Versus Socio-Politics. EcoHealth, Vol 13; 618-622 https://link.springer.com/article/10.1007/s10393-016-1177-x

(OECD) created policy to reduce lead addition to natural and human environments during the 1990s (OECD, 1993, 1994). The USA and the EU proposed an OECD Council Act to effect a reduction in the use of certain specified forms of lead (OECD, 1995), but did not specify lead shot. The Lead Working Group of the OECD identified lead shot as a major candidate for inclusion in an OECD Council Act (OECD, 1994), but in the absence of renewed coercion from these and other international agencies (such as the Nordic Council of Ministers (Thomas and Owen, 1996)) political interest waned (Thomas, 2010). All that remains is the voluntary agreement between FACE and Birdlife International of 2004. The Federation of Hunting Associations of the European Union (FACE) signed an agreement with Birdlife International in 2004 under Directive 79/409/EEC (Birds Directive) seeking a phase-out of the use of lead shot in hunting in wetlands by 2009 at the latest (European Commission, 2004).

The most progressive legislation in Europe is provided by Denmark which, since 1996 has required lead-free ammunition to be used for all shotgun hunting and non-Olympic target shooting. Enforcement of the law, and thus hunter compliance, is enhanced by prohibiting the import, possession, and use of lead shot cartridges (Kanstrup 2006). Denmark also plans to ban the use of lead-core rifle ammunition and has shown that cost-effective alternatives exist (Kanstrup *et al*, 2016a,b)[251]. A few existing examples of legislation requiring use of lead-free rifle ammunition for game hunting in Europe exist i.e. Sweden and Mauritania (Avery and Watson 2009), and some parts of Germany (Krone et al. 2009).

The following table summarizes restrictions related to the use of lead ammunition and sinkers in the EU (See Table 46).

[251] Kanstrup *et al* (2016): The transition to non-lead rifle ammunition in Denmark: National obligations and policy consideration. Ambio 2016; 45(5): 621-8: https://www.ncbi.nlm.nih.gov/pubmed/27040101; Kanstrup et al (2016b) Efficacy of non-lead rifle ammunition for hunting in Denmark. European Journal of Wildlife Research, June 2016; 62; 3, 333-340: http://link.springer.com/article/10.1007/s10344-016-1006-0

Table 46. Legal situation regarding uses of lead ammunition and sinkers in the EU

Country	Ban of lead shot use for hunting waterfowl and/or in wetlands	Ban of lead shot use for hunting in upland areas	Ban of lead use for clay target shooting	Ban of lead sinkers use in inland waters
Austria	no	no	no	no
Belgium	yes	yes in Flanders in 2008	no	no
Bulgaria	no	no	no	no
Cyprus	yes	no	no	no
Czech Republic	yes	no	no	no
Denmark	yes	yes	yes	yes
Estonia	no	no	no	no
Finland	yes	no	no	no
France	yes	no	no	no
Germany	yes in 8 out of 16 regions	no	no	no
Greece	no	no	no	no
Hungary	yes	no	no	no
Ireland	no	no	no	no
Italy	no	no	no	no
Latvia	yes	no	no	no
Lithuania	no	no	no	no
Luxemburg	no	no	no	no
Malta	no	no	no	no
Netherlands	yes	yes	yes	no
Poland	no	no	no	no
Portugal	yes	no	no	no
Romania	no	no	no	no
Slovakia	yes	no	no	no
Slovenia	no	no	no	no
Spain	yes	no	no	no
Sweden	yes	yes	yes	no
United Kingdom	yes in Great Britain	no	no	yes in England and Wales

Source: Limitations of European Union policy and law for regulations use of lead shot and sinkers. Environmental Policy and Governance, 20;57-72 (Thomas, 2010)

Denmark, The Netherlands and Sweden have made progress in passing national laws that ban lead shot in hunting (Mateo, 2009; Thomas 2010). A range of action on this issue exists in European Union (EU) countries, including non-recognition of the issue (Mateo, 2009; Thomas, 2010). Where the use of lead shot is restricted, measures apply only to wetland situations, and very few provisions apply to the deposition of lead shot in upland habitats (except Denmark, The Netherlands and Sweden). No progress has been made at the wider European level to require use of non-toxic substitutes (Thomas, 2010). Before the introduction of REACH the EU commissioned a study (Hansen *et al.*, 2004) of lead deposition in European habitats from shooting and fishing, and the advantages/ disadvantages of requiring lead substitutes. However, there was strong opposition from hunting and shooting groups and no legislative action has been implemented (Thomas, 2010).

The EU chemicals regulation, REACH (Registration, Evaluation and Authorisation of Chemicals), became law in 2007. Under REACH, any substance manufactured or imported in quantities at or above one tonne per year requires registration and testing, with progressively stricter requirements for larger-volume substances. The European Chemicals Agency (ECHA) announced its intention to produce a REACH registration dossier on lead in ammunition in April 2016 noting the following:

'*Lead in gunshot may pose a risk to human health and the environment, in particular to aquatic bird species. Several reports link the eating of spent shot with the deaths of ducks and all species of birds. Reports are also warning about possible risks to people who eat game meat, such as pheasants. Many EU Member States already have national legislation in place to restrict the use of lead in shot. In addition, there is an International Agreement on the Conservation of African-Eurasian Migratory*

Waterbirds (AEWA) under the auspices of the UN Environment Programme, to which the EU is a party.

To manage the risks, harmonise the conditions of use throughout the EU and adhere to the international agreement, the European Commission requested ECHA to assess the risk and the need for phasing out lead shot in wetlands.

The intention to prepare a restriction dossier was announced in April 2016. There is also a call for evidence to gather more information on the issue. In the coming months, ECHA will organise a workshop to inform its stakeholders of the restriction initiative and to gather further information on lead in shot.

Furthermore, the Agency is now collecting information for the assessment of the risk and the socio-economic impact for other uses of lead in ammunition. These include hunting in terrains other than wetlands, target shooting as well as using lead weights for fishing. In its assessment, ECHA will pay special attention to aspects related to animal welfare in hunting and preventing accidents to hunters and sport shooters. If the risk is demonstrated, this might lead to the preparation of a separate dossier for restriction.'[252]

The final REACH Report is expected in Spring 2017.

Comparison of EU Actions on Other Forms of Lead in the Environment: Marked inconsistency of policy exists within the EU regarding the removal of lead products (Thomas 2011). Removal under directives has occurred when lead was part of the human environment as in paint, glass, wheel weights, solders, and petrol. However, no broad action has been followed when lead pollution is part of wildlife's environment (Thomas, 2010). This inconsistency, or lack of coherence, in EU policy and law has been commented on by Onida (2004) and Thomas and Guitart (2005). In this regard, the EU is similar to North America, in that regulating against the use of lead has proceeded on a product-by-product basis. A ban on the use of lead in one product has not acted as a precedent for its removal from all other products (Thomas, 2010)

Thomas (2010) notes that 'lead poisoning of wildlife has been relegated to the agencies representing wildlife (rather than agencies dealing with broad pollution issues), and within them the separate representatives for sport shooting and angling deliver their individual positions (see Hansen *et al.*, 2004, and EFTTA, 2008, for the EU, and Rattner *et al.*, 2008, for the USA). It is easy to understand why a ban on the use of lead sinkers in the UK in 1987 was not reciprocated immediately by a ban on the use of lead shot for all game shooters, given the different social constituencies involved, their different perceptions of the environmental problem and their respective political power (Thomas, 1997). Few countries that have banned lead shot have extended the ban to use of lead sinkers Thomas (2010) concludes: 'All shooting and angling are recreational industries that are now inadequately regulated across Europe. The human components of this industry manufacture, transport and release a known potentially toxic material (lead) that persists in all the environments where it is ultimately deposited. Other industries that use lead (e.g. battery makers, lead smelters) that may be released to environments must comply with stringent legal conditions of emission, practice recovery and remediation, and adopt new technology to achieve compliance. It is anomalous that the shooting and angling industries are not yet subject to the same legal constraints deemed necessary for other industries, despite available non-toxic substitutes. Resistance to proposed bans on the use of lead shot and sinkers is intense, both within each party to the EU and across the EU. The resistance was focused initially on perceived limitations of steel shot and higher costs of lead substitutes. However, the advent of materials with ballistic properties rivalling or exceeding those of lead has provided an array of effective lead substitutes.'

Thomas (2010) questions the validity of arguments that substitutes are too expensive to use. The costs of using lead substitutes have been examined (Hansen *et al.*, 2004), but not the economy of scale argument, as when

[252] ECHA Newsletter May 2016 No. 2: https://newsletter.echa.europa.eu/home/-/newsletter/entry/2_16_reach-restrictions-underway-for-lead-and-tattoo-inks-where-are-we

mandatory use of non-toxic substitutes would cost all consumers less. Inclusion of North America and Europe in a single non-toxic market for ammunition would expand further the economy of scale. Thomas (2010) observes that 'in EU countries, hunting is the sport of the affluent, who pay highly for the costs of their game. Prices to shoot birds vary according to species, country, estate and time of the season, but are well above 20 euros a bird for driven bird shooting. Non-toxic shot cartridges made of materials other than steel are approximately 1.5–2 euros each, while steel shot cartridges are about the same price as high-quality lead shot cartridges. The added costs of non-toxic cartridges are not onerous. The collective experience of hunters in Denmark, Norway, The Netherlands and other non-European countries that have banned lead shot is that using lead-free products has not diminished the recreational value of hunting. The two arguments against change (costs and effectiveness of substitutes) have not prevailed.'

The World Forum on the Future of Sport Shooting Activities (WFSA) supports the use of lead shot in shooting (WFSA, 2004). The Olympic Games organization has also resisted using non-toxic shot in shotgun shooting, claiming that the shooting during the actual games results in little lead shot contamination (Thomas, 2010). What is not considered is the amount of lead deposited by every nation's training teams and aspiring competitors during the four years between Olympic Games. This is conservatively a tonne of lead annually, per shooter, often in environments where reclamation is never considered, let alone practiced. Steel shot could be easily accommodated by such games, with little change in rules, equipment or facilities (Thomas, 2010).

Marketing Issues That Confound Non-Toxic Shot and Sinker Use: The EU shotgun cartridge industry is large and has an annual value of about 300 million euros (Hansen *et al.*, 2004: Thomas 2010). About 40,000 tonnes of lead and other associated metals are used as shot, annually, for hunting, most of which is discharged to the environment (Thomas 2011). This lead remains potentially available to birds to ingest for decades and even centuries (Mateo *et al.*, 1998; Darling and Thomas, 2005). The US and Canadian requirement for use of non-toxic shot for hunting migratory waterfowl has created a large market for non-toxic ammunition. Industry and a competitive marketplace have responded with multiple approved non-toxic products (USFWS, 2006; Thomas 2010). It is the combination of the legal requirement to use non-toxic materials and the US capacity to enforce use of lead-free shot on private and public lands that has created the assured market for non-toxic shot in the USA and Canada. The weak enforcement provisions within most EU countries have not encouraged a strong market for non-toxic ammunition (Thomas, 2010).

Thomas (2010) notes that shot made from soft steel cannot be patented. Steel shot ammunition is manufactured and marketed throughout those European countries that require some measure of non-toxic shot use. Most steel shot used in North American shotgun cartridge manufacturing is produced in China and then imported into the US. commercial cartridge makers. Switching from lead can produce steel shot because no proprietary, or technological, barriers prevent this (Thomas, 2010). However, non-toxic ammunition shot materials approved in the USA have patent protection. In a European context, patent infringement issues could be avoided by European manufactures by establishing a commercial manufacturing or distribution agreement. For this to occur, legislation requiring use of lead-free shot and enforcement of its use would have to exist to assure any company of a sizeable and profitable market. Tungsten-Matrix® shot (made in the UK) is distributed in this way in The Netherlands and Denmark, where the ban on the sale of lead shot affords an assured, although small, market (Thomas 2010). This emphasizes the importance of legislative reform i.e. the problem of lead poisoning is established, nontoxic ammunition is available, but the legislation to effect the sustainable solution is limiting (Thomas, 2010). The patent issue is not considered significant in the Canadian context since the vast majority of the market in Canada is supplied by US companies that already supply the non-lead alternatives and hold the patents.

It is important to remember that while lead poisoning was associated initially with waterfowl, it is now recognized that lead poisoning of upland species and raptors is as serious (Kendall *et al.*, 1996; Fisher *et al.*, 2006; Pain *et al.*, 2009; Thomas 2010). The segregation between the upland and wetland situations reflects the bias of early investigations towards waterfowl and not the actual prevalence of lead toxicosis among all bird species (Scheuhammer, 2009; Thomas, 2010).

Thomas (2010) concludes that the geographic ranges of Eurasian migratory birds transcend most nations of the EU, so a common EU approach is required. EU legislators could adopt a 'wetlands first' approach, or they could adopt the same policy and legal approach of Denmark, The Netherlands and Sweden, and ban lead shot used

for all game hunting. A total phase-out of all lead use would bring the associated benefits of an expanded economy of scale, greater ease of enforcement and hunter compliance, and an earlier date for halting the enormous annual tonnage of lead deposition in EU environments (Thomas, 2010).

5.5 Why the transition to non-toxic ammunition is so difficult – lessons from other jurisdictions (UK and US)

In the UK compliance with the current regulations[253] restricting use of lead shot in England in order to reduce the pollution of wetlands and poisoning of wildfowl has been shown to be poor[254] and morbidity and mortality remains high across Britain. A high profile campaign run by the UK Department of the Environment and Rural Affairs (DEFRA) and shooting organisations to reduce illegal use of lead shot was ineffective in increasing compliance.

Cromie *et al* (2015)[255] examined the resistance to change from many in the recreational shooting community in the UK despite the fact that the replacement of lead ammunition with nontoxic alternatives is widely recognised as a practical and effective solution to address the risks. To better understand the situation, Cromie *et al* (2015) conducted a survey of shooters' behaviours and attitudes, combined with a review of coverage of the subject area in the shooting media. Together with personal experiences of the authors, the study highlights a number of sociological and political barriers that combine to inhibit both compliance with existing regulations and a transition to wider use of non-toxic ammunition.

Cromie *et al* (2015) note that it took many decades of science and policy development (often associated with industry resistance), to reduce exposures of people to lead in paint, petrol and pipes on a global scale (Stroud 2015). The authors also note that the scene is now set for change on use of lead ammunition: the evidence is extensive and robust (Group of Scientists 2013, 2014);[256] there are clear international and national policy drivers (Stroud 2015);[257] ammunition users are not being asked to stop their current activities, they are being asked instead to use different ammunition, which is increasingly available; and has a range of benefits (e.g. reduced wildlife toxicity, reduced lead exposure of humans via game meat). Despite this, resistance to change remains firm amongst many in the shooting community. A publication in the autumn of 2012[258], indicating a continuing problem of lead poisoning in waterbirds in Britain, gained some media coverage in the UK and this created heightened tension in the debate and was met with a strong negative reaction in the UK shooting media and shooting organisations. Since then, retaining the current *status quo* has been strongly argued for by the two main UK shooting organisations (BASC and Countryside Alliance).

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[253] As a Contracting Party to the African-Eurasian Migratory Waterbirds Agreement (AEWA), the UK has an obligation to phase out the use of lead shot over wetlands (AEWA 1999, 2002, 2008) (with the initial deadline for this being 2000). Consequently, restrictions on the use of lead shot were introduced in England in 1999 (HMSO 1999, 2002a, 2003), Wales in 2002 (HMSO 2002b), Scotland in 2004 (HMSO 2004) and Northern Ireland in 2009 (HMSO 2009). In England and Wales, the Regulations make it illegal to use lead shot for shooting wildfowl, coot *Fulica atra* and moorhen *Gallinula chloropus*, and over certain listed wetlands (Sites of Special Scientific Interest) and the foreshore. In Scotland and Northern Ireland the use of lead is not permitted over any wetlands.

[254] In the 2013/2014 UK game season 77% of ducks were found to be shot illegally with lead (Cromie et al., 2015)

[255] Cromie *et al*. 2015. The sociological and political aspects of reducing lead poisoning from ammunition in the UK: why the transition to non-toxic ammunition is so difficult. p104-124. , In: R.J. Delahay and C.J. Spray (Eds.). Proceedings of the Oxford Lead Symposium. Lead Ammunition: understanding the risks to human and environmental health, December 8, 2014. The University of Oxford, Edward Grey Institute.

[256] Group of Scientists (2013). Health risks from lead-based ammunition in the environment: a consensus statement of scientists. March 22, 2013 Available at: http://www.escholarship.org/uc/item/6dq3h64x. Group of Scientists (2014)**.** Wildlife and human health risks from lead based ammunition in Europe: a consensus statement by scientists. Available at: http://www.zoo.cam.ac.uk/leadammunitionstatement/.

[257] Stroud DA 2015. Regulation of some sources of lead poisoning: a brief review. P8-26: In: R.J. Delahay and C.J. Spray (Eds.). Proceedings of the Oxford Lead Symposium. Lead Ammunition: understanding the risks to human and environmental health, December 8, 2014. The University of Oxford, Edward Grey Institute.

[258] Newth *et al.2012. Poisoning from lead gunshot: still a threat to wild waterbirds in Britain. European Journal of Wildlife Research. DOI: 10.1007/s10344-012-0666-7.*

Despite some examples of shared conservation objectives and collaborative projects, the relationship between the shooting sports and conservation communities remains problematic (Cromie *et al*., 2015). The lead debate in the UK continues to be conducted in a general environment of mistrust and tension which has increased in recent years due to concerns over the sustainability of shooting practices overall, and a perception that conservation organisations are anti-hunting / anti-gun (Cromie *et al.,* 2015). There is also a legitimate perception among hunters and shooters in general that legislation is one-way and only leads to further restriction on their sports.

In 2012, the UK Department of Environment and Rural Affairs (DEFRA) conducted an extensive campaign to promote compliance with the requirement to use non-toxic shot to hunt waterbirds with no impact – compliance was ~30% between 2002 and 2012 and dropped to 23% in the 2013/2014 season. The survey of hunters, and the themes found in the shooting media, showed three main reasons for non-compliance:

1. "Lead poisoning is not a sufficient problem to warrant restrictions" *i.e.* shooters were not convinced of the morbidity and mortality caused and thus the need for the regulations (indeed the media survey found frequent reference to 'never seeing bodies');
2. "Don't like the alternatives", shooters reporting that they felt the non-toxic alternatives were too expensive, not effective and/or not widely available;
3. "Not going to get caught" *i.e.* shooters knew that using lead would not involve penalties as the law is not enforced.

The top two reasons for resisting transition to non-toxic ammunition in the UK are entirely consistent with the top reasons given by hunters and shooters in Canada.

Cromie *et al*., (2015) decided to further investigate the above-mentioned reasons from the shooter questionnaire survey and themes from the shooting media survey since these were likely to create motivation to resist either current regulations or future complete transition to non-toxic ammunition. Cromie *et al.,* (2015) made the following conclusions:

"Lead poisoning is not a sufficient problem": Shooters are not convinced that this is a significant cause of mortality: Pain *et al.* (2015) estimate in the region of 100,000s of game birds and wildfowl dying of lead poisoning annually. Lead poisoning, as a disease, suffers from the same problems of perception as other insidious (often chronic) diseases which, by their nature, are often largely unseen by most people. It is likely that the overwhelming majority of shooters have no direct experience of the deaths and illness of wildlife caused by the ingestion of lead ammunition. To date, the conservation community has failed to persuade the shooting community of the substantial problem and impacts of lead poisoning. Publishing science is valuable for scientists and policy makers but may have little impact on broader societal understanding in the absence of interpretation of that science for the benefit of specific audiences (Cromie *et al*., 2015). Awareness-raising tools have been shown to have a beneficial role if targeted on specific weaknesses in knowledge that are most directly related to attitude and behaviour change. However, with such a strong narrative within the shooting media that lead poisoning is not a (significant) problem, awareness-raising of the issue within the shooting community would have to firstly address the prevalent narrative which would involve politically difficult changes of organisational positioning. Thereafter, awareness-raising would rely on building communication of tailored messages using appropriate tools (*e.g.* video and images, infographics, facilitated workshops *etc.*), most importantly delivered by *trusted* and credible messengers (AEWA 2009; Cromie *et al,* 2015). Who these messengers may be is difficult to identify as those involved in dealing with lead poisoning are often portrayed as anti-shooting and there is a perception that lead is used as a scapegoat for an anti-hunting/anti-gun agenda.

"Don't like the alternatives": This includes concerns regarding price, efficacy and availability: this has been a serious barrier in other countries (*e.g.* AEWA 2009), and was found to be important in the UK survey, and is also a key reason from many Canadian shooters/hunters. Techniques such as non-toxic ammunition shooting clinics/demonstrations, run by shooters, which demonstrate the efficacy of non-toxic ammunition, have been shown to work well to help change perception of non-toxic ammunition (AEWA 2001, Friend *et al.* 2009). Economies of scale and market forces, particularly when markets are guaranteed *i.e.* following legislative requirements (Kanstrup 2010) could potentially help to bring down the price of some of the less frequently used non-toxic ammunition types (steel, the most frequently used non-toxic shot type across the world, is more

comparably priced to lead) whereas other alternatives (e.g. bismuth and tungsten) are significantly more expensive. Cromie *et al*. (2015) notes ammunition forms a small part of the costs of hunting.

"Won't get caught": A lack of enforcement in the UK is the reason for the hunters stating that they don't expect to get caught using lead illegally – with only one conviction in 15 years despite a very high non-compliance rate. To combat this greater enforcement or licencing measures are proposed by Cromie *et al* (2015). In the Canadian context, high non-compliance with existing regulations for non-toxic shot is not expected to be an issue in Canada. However, the high non-compliance rate observed in the UK (in the absence of effective enforcement, combined with knowledge of the strong resistance to change in the shooting community), could be viewed as a cautionary note regarding the potential for success for voluntary measures to reduce lead use in ammunition in Canada.

Several other barriers to the adoption of non-toxic shot were also identified by Cromie et al (2015) including:

Tradition: Shooting and wider hunting activities are deeply traditional. The word "traditional" is often used by shooters to describe themselves or their pastime and likely involves a range of concepts such as fine old gun craftsmanship, inherited stories and guns, pride in maintaining tradition, and a sense of wanting to be out in the countryside and free of intrusive regulation (Cromie *et al*., 2015). Persuading individuals to adopt what are seen as 'non-traditional' behaviours is complex yet can be achieved if the issue becomes unacceptable to society and benefits clearly outweigh the costs *e.g.* wearing seatbelts or not smoking in enclosed public spaces. These examples involved great initial resistance to change. Tackling change to the tradition of using lead ammunition is likely to involve a combination of reduction of the barriers outlined here, a clear establishment of the costs of not changing, the benefits of changing (including more birds to shoot), and leadership from the shooting community and/or from influential, respected and trusted individuals from within the hunting/shooting community (Friend *et al*, *2009,* Cromie *et al.,* 2015). Note that in Denmark, the cultural acceptance/tradition of using non-toxic shot (accepting that they had no choice after a national ban on lead ammunition) has become established since their transition in 1996 (Kanstrup 2015; Cromie *et al.,* 2015).

Polarized debate: Cromie *et al* (2015) note that in the UK the opportunity for the conservation and shooting communities to work together to address the above issues following the introduction of the regulations across the UK was missed. This is similar to a point made by Friend et al (2009) when discussing the history of the lead shot ban in wetland in the US (further discussed later in this section). In the UK at that time there was likely a sense that the job was done and that the law would be obeyed. Despite information about the law and the use of non-toxic alternatives being made available on a shooting association website, Cromie *et al* (2015) suggest that, with hindsight, hearts and minds of the wider shooting community had probably not been won. Cromie *et al.* (2015) notes that it would have been valuable at that time to have prioritized development of collaborative persuasive resources concerning the actual problem of lead poisoning as well as the efficacy of the non-toxic shot. Since that time there have been developments in the UK, including wider understanding of risks of lead ammunition to wildlife, livestock, humans and the wider environment, plus the associated calls and policy drivers for its substitution with non-toxic alternatives. However, as the "threat to lead ammunition" has emerged and change has become more likely, the discourse has become more polarised with a recurring narrative of this being "an attack on shooting" (Cromie *et al.*, 2015).

The shooting media survey elucidated a prevalent theme of the 'evidence for needing change is absent or invented/ exaggerated'. Social scientists may term this mistrust as 'biased assimilation' where, in polarised debates, either side may seek and assimilate evidence that reinforces their current beliefs and existing attitudinal position and reject the contradictory counterargument (Cromie *et al*, 2015).

Cromie suggest that the current debate in the UK may be termed 'solution aversion' whereby an objection to the possible solution (in this case transition to non-toxic ammunition) results in the scepticism about the seriousness of the problem even if it is based on sound science – this is also called 'motivated disbelief' (Campbell and Kay 2014; Cromie *et al.,* 2015). If the debate is being framed within this context, although there is often a call from the shooting community for more evidence (*e.g.* Ali 2015), it would suggest that further evidence is unlikely to be accepted by the shooting community if the solution to the problem remains undesirable (Cromie *et al.,* 2015). Within the debate on lead ammunition it would seem that a practice has developed of discrediting the evidence, the providers of evidence, and the messengers of unpalatable messages (Cromie *et al.,* 2015).

Friend *et al.* (2009) provides some similar perspectives to Cromie *et al* (2015) based on the US experience. Friend *et al* (2009) reviewed key events associated with the transition from the use of lead shot to nontoxic shot for waterfowl hunting in the US and highlights key points for consideration by those engaged in attempts to further reduce lead exposures in wild birds. Current arguments for retention of lead within the US for traditional uses in hunting, fishing, and shooting sports are similar to those of the past. Friend *et al* (2009) suggests that it is prudent for those seeking further reductions of lead poisoning in wildlife to be fully cognizant of the transition, conflicts, and factors that facilitated resolution of the lead poisoning issue in waterfowl. Application of this knowledge should expedite further transitions in the replacement of existing traditional lead uses in these sports so that past mistakes are not repeated (Friend *et al.,* 2009). Some key observations highlighted by Friend et al (2009) include;

- To a large extent, "public education" needed to begin within the conservation agencies, because there were many employees who interfaced with hunters and other members of the public who knew too little about lead poisoning and/or were opposed to nontoxic shot use. Further, reaction drove public education efforts for too long and was a poor substitute for a progressive, well-rounded education program. The Fish and Wildlife Service did organize educational programs however these occurred after tensions regarding the proposed ban had already developed hence some of these forums were aggressively hostile towards presenters supporting nontoxic shot. FWS representatives commentary and response to questions were disrupted, and in some instances, their safety was threatened.
- The encouragement of hands-on involvement by the public were powerful tools for "perspective and attitude adjustments" regarding the lead poisoning issue. A case in point is the assistance of Wisconsin hunters in the clean-up of a major lead poisoning die-off of Canada Geese. Another example is the encouragement of hunters in conducting their own lead shot ingestion studies using gizzards from birds they personally harvested. Steel shot shooting clinics were invaluable educational forums for influencing hunters.

In asking the question "What has been accomplished?" Friend *et al* (2009) concludes that the implementation of nontoxic shot requirements for hunting waterfowl in the US has dramatically reduced lead shot ingestion by waterfowl and subsequent losses from lead poisoning. Anderson *et al.* (2000) found in their 16,651 samples from the Mississippi Flyway during 1996 and 1997 that gizzards of 44% to 71% of major duck species contained only nontoxic shot. These authors estimated that non-toxic shot reduced mortality from lead poisoning in Mississippi Flyway Mallards by 64% and extrapolated their data to a saving from lead poisoning of 1.4 million ducks nationwide in the 1997 fall continental flight of 90 million ducks (Anderson *et al*. 2000). Smaller scale post-nontoxic shot implementation evaluations also disclosed major reductions in lead exposure (DeStefano *et al*. 1995, Calle *et al.* 1982; Friend *et al.,* 2009). However, Friend *et al* (2009) also writes that although "a strong science-based foundation is requisite for further transitions to nontoxic ammunition and fishing weights. Our experiences have taught us that the societal aspects of this transition are as important as the biological components and must be adequately addressed before alternatives to toxic lead ammunition, fishing weights, and other materials will be accepted as an investment in wildlife conservation." In addition, "Little of what we have presented here reflects the bitterness that characterized much of the struggle to transition to the use of non-toxic shot for waterfowl hunting in the US. Nor does it reflect the heavy personal costs to those who championed the use of nontoxic shot, among them state and federal employees, outdoor columnists, members of the general public, academicians, researchers, and others."[259]

Overall, the current polarized debate and its powerful players continue to create significant barriers to change in key jurisdictions (Friend *et al.,* 2009; Cromie *et al.,* 2015).

[259] Friend *et al* (2009**).** Biological and societal dimensions of lead poisoning in birds in the USA. In: Watson RT, Fuller M, Pokras M, Hunt WG (eds). *Ingestion of lead from spent ammunition: implications for wildlife and humans*. The Peregrine Fund, Boise, Idaho, USA. pp 34-60.

The above discussion focuses on key jurisdictions considered most relevant to the debate on management measures for lead ammunition. Avery and Watson (2009) reviewed lead ammunition regulation in all jurisdictions around the world and a summary of their findings is provided in Appendix 4.

5.6 Summary of Pros and Cons in the Canadian Context

Although the pros and cons of implementing the measures and management practices discussed in 5.1-5.4 in the Canadian context are discussed alongside the specific details of the measures where relevant, the following summary of the key findings are provided below:

Partial or Full Ban on Lead Ammunition:

Canada vs European Examples: Restrictions in Norway on using lead to hunt outside of wetlands were introduced in 2005, under one political regime, and repealed in 2015 with a change in the political climate. Similar proposals for lead ammunition bans have been proposed and subsequently abandoned or defeated in other countries and some US States. One aspect that is consistent between all these cases is strong opposition from politically influential hunting/shooting lobby groups. Denmark, The Netherlands and Sweden banned lead ammunition for all hunting/shooting, despite opposition from hunting/shooting lobby groups, and with no evidence of subsequent negative economic impacts. The pros and cons of increasing restrictions on lead ammunition (partial to full bans) similar to the examples above in Canada are as follows:

Con: Whether an extended partial ban or full ban is proposed, hunting/shooting lobby groups will oppose any proposed action on lead ammunition and the same arguments will be used despite an accumulation of scientific evidence that the claims made are not scientifically defensible (e.g. there are no problems with lead, non-lead ammunition does not work as well, the increased costs will result in less people hunting/lost jobs, etc). These arguments will be used in Canada in the event that any action on lead ammunition is proposed. As with other jurisdictions, many hunting/shooting stakeholders in Canada will refuse to discuss or accept the balance of scientific evidence. The success in implementing lead ammunition controls appears to reflect the relative political influence of the hunting/shooting lobby groups in the country at the time rather than the balance of scientific evidence.

Pro: The balance of scientific evidence for further restrictions on lead ammunition is strong. Other jurisdictions have banned the use of lead ammunition based on the available evidence (e.g. Sweden, The Netherlands, Denmark). Stakeholders outside of the hunting/fishing lobby that have evaluated the evidence in an objective way support action on lead ammunition.[260]

Pro: Countries that have banned lead in hunting and shooting have shown no evidence of reduced participation or economic impacts. The analysis in this report indicates the same would be expected for Canada.

Pro: Prohibiting the uses of lead ammunition in shooting sports and hunting in Canada would be expected to reduce both human and wildlife lead exposures.

Pro: There is evidence from various jurisdictions that prohibiting the use of lead ammunition results in clear benefits for wildlife populations. This includes data from Canada following the restrictions under the *Migratory Birds Convention Act* (see section 5.2).

Canada vs US Examples: The US has struggled to apply national restrictions on lead ammunition beyond the *Migratory Birds Treaty Act* largely due to a lack of Federal Authority (ammunition is exempt from TSCA) and due to powerful lobby groups that support continued use of traditional ammunition. Some US states have introduced additional controls beyond the *Migratory Birds Treaty Act* restrictions with California going the furthest in banning all uses of lead ammunition by 2019 despite strong opposition from the hunting/shooting lobby. Lack of action by other states appears to be associated with strong opposition from powerful hunting/shooting lobby groups.

[260] E.g. Canadian Wildlife Health Cooperative www.cwhc-rcsf.ca

Voluntary efforts to reduce lead ammunition uses by US States have achieved limited success, where success has been achieved free non-toxic ammunition has been provided to hunters.

Con: Any proposed action on lead ammunition in Canada will meet the same opposition from hunting/shooting lobby groups as has been observed in the US.

Con: The most progressive action on lead ammunition has succeeded in situations where iconic and charismatic species have been used as 'poster animals' to illustrate the need for change. For example, in the US - the poisoning of eagles; in Canada - the poisoning of loons, in the UK – the poisoning of swans; in California – the poisoning of Condors. Even in these cases, regulators have had to deal with strong opposition from hunting/shooting groups. Clearly, these iconic species are not the only animals being exposed to lead from ammunition and being subjected to the resultant adverse impacts, but they are species with a status that has helped facilitate action in spite of strong lobbying efforts opposed to any action on lead ammunition. California was able to gain support for the ban based on concerns regarding lead toxicity and lead-induced mortality in a critically endangered and iconic species (Condor). It was likely easier for California to present a clear case and argue for prompt action using the Condor as an example – a highly-valued species that could otherwise go extinct – hence making it more difficult for certain stakeholders to deny there was a problem. National action in Canada would not be based on a simple argument to save a single iconic species – it would be based on the balance of scientific evidence for human and wildlife toxicity. Many influential hunting/shooting community stakeholders in Canada have shown that they are opposed to providing data for study and are not even willing to discuss the scientific evidence. There are shooting/hunting stakeholders in Canada more willing to provide information and discuss the issue but they appear to be in the minority currently.

Con: In US States, voluntary reductions in lead ammunition use have achieved limited success and the same limited success of this approach would be expected for Canada based on the clear reluctance of hunters/shooters to change. States with evidence of voluntary success are handing out free non-toxic ammunition to hunters. Once the funding for this free ammunition ceases it is unclear whether hunters will continue to use lead-free ammunition.

Pro: Importantly, Canada does not have the same legislative restriction at the Federal level under CEPA as the US EPA has had under TSCA - as lead ammunition manufacturing, import, sale and use can be controlled under CEPA.

Pro: California has provided an additional example, and one in North America, where concern regarding lead wildlife toxicity has resulted in a total lead ammunition ban.

Pro: US manufacturers of ammunition, also the main suppliers of ammunition to Canada, already make lead-free alternative ammunition for all applications. The increased demand for lead-free ammunition due to the California ban is likely to improve the availability and economies of scale for lead-free ammunition in North America. This could increase the availability and reduce the cost of alternatives for the Canadian market.

Pro: To date, most of the scientific literature regarding the toxic impacts of lead ammunition has focused on wildlife toxicity and specific species of birds. There is now increasing evidence for wider impacts on both wildlife and humans due to the toxicity of lead ammunition. Examples include recent evidence for human health impacts associated with lead exposure through game meat and indoor shooting ranges from Canadian studies. Such Canadian specific data, along with the large body of evidence that exists from international studies, provides a strong and growing scientific basis for regulatory action in Canada.

Pro: A prohibition on lead ammunition, similar in scope to California, but applied in Canada under CEPA (e.g. prohibiting the manufacture, import and sale of lead ammunition in Canada) would be expected to reduce the exposures of wildlife and Canadians (e.g. those that eat game meat and/or are exposed to lead due to participation in shooting sports) to lead. This would be consistent with the Government of Canada's overall risk management objective (RMO) which is to reduce exposure to lead to the greatest extent practicable by strengthening current efforts in priority areas where the government can have the greatest impact upon exposure of Canadians.

6.0 Overall Summary

The recent 'State of the Science' Report by Health Canada (Feb 2013) noted that the current Canadian blood lead intervention level is 10 µg/dL, however, since the establishment of that blood lead intervention level, scientific evidence has been published that demonstrates critical health effects occur below 10 µg/dL. The risks associated with lead include developmental neurotoxicity, neurodegenerative, cardiovascular, renal and reproductive effects. Environmental risks include toxicity to wildlife. The Government of Canada therefore developed a Risk Management Strategy (RMS) for lead that outlines actions to further reduce risks associated with exposure to lead. The overall risk management objective (RMO) is to reduce exposure to lead to the greatest extent practicable by strengthening current efforts in priority areas where the government can have the greatest impact upon exposure of Canadians. Several sources of potential lead exposure of the general population and the environment remain a concern and require further analyses. This study is focused on the continued uses of lead in ammunition in Canada.

Global production of ammunition is dominated by industrialized mass manufacturing. There is relatively little ammunition manufacturing activity in Canada. Most ammunition used in Canada is imported and >90% of imported ammunition comes from the US. The major importers are ammunition manufacturers, distributors and retailers. Ammunition end-users include hunters, sport shooters and law enforcement officers. It appears that the current market for ammunition in Canada (excluding military applications) continues to be dominated by lead, and the only real market for non-lead ammunition is the legislated non-lead market under the *Migratory Birds Convention Act*.

The amount of lead in each ammunition cartridge varies depending on whether the cartridge is designed for use with a shotgun (lead shot or slugs used in shotgun cartridges) or contained within the projectile used in a rifle/pistol cartridge. Within both the shotgun cartridge and rifle/pistol categories there are also a wide variety of different sizes of shotgun cartridges and bullets to choose from containing varying quantities of lead.

The major facilities that allow the use of ammunition on site are various types of shooting ranges. Various sport shooting activities can take place at shooting ranges (target shooting (indoor and outdoor) trap and skeet, sporting clays etc.) and vary depending on the individual range and the available facilities. It is estimated that there are approximately 1025 shooting range locations in Canada with a total membership of >225,000. This indicates that on average ~10% of firearms licence holders are range members. It was estimated that 65% of shooting range locations in Canada contain rifle ranges, 64% contain handgun ranges, and 41% contain shotgun ranges. The number of members per range varies widely depending on the range size. Based on available data the average number of members per range in Canada was estimated to be 192 members per range. There appears to be limited reclamation of spent lead from shooting ranges in Canada currently.

Estimates for the uses of lead and non-lead ammunition in hunting, shooting sports, and law enforcement were developed based mainly on publicly available data since most stakeholders (including ammunition manufacturers, importers, distributors and retailers) refused to provide data for the study. We know that on average 375 million ammunition cartridges are imported into Canada each year as reported to NRCan under the *Explosives Regulations*. There is minimal domestic manufacturing (95 tonnes of lead shot reported to be produced annually in Canada). It is estimated that approximately 5,000 tonnes (possible range 3,500-7,000 tonnes) of lead are used annually in ammunition for shooting sports and approximately 40 tonnes (possible range 14-80 tonnes) of lead is used in hunting ammunition. Uses of lead ammunition for law enforcement are estimated to be ~120 tonnes per annum. These estimates could be refined with further input from lead ammunition supply chain stakeholders and, since voluntary submission of data is not expected, a CEPA Section 71 survey could be used for this purpose.

It appears that very little lead from spent ammunition is recovered and hence most lead used in ammunition is lost to the environment. The popularity of shooting sports has grown over the past 5 years and is trend is expected to continue, hence increased uses and releases of lead via ammunition are expected over the next 10 years with annual lead releases to the environment increasing from ~5,000 tonnes in 2016 to ~5,800 tonnes in 2025. Increased uses of alternatives to lead are not expected in the BAU scenario as many end users of ammunition are very resistant to change, refuse to discuss the science regarding the toxicity of lead

ammunition, deny there is a problem, continue to argue that the alternatives and don't work despite evidence to the contrary, and have indicated that any discussion on lead in ammunition is an unfair attack on their sport and gun ownership in general. In addition, alternatives are more expensive than lead and ammunition users appear to be very price sensitive even though ammunition is a very small portion of the overall expenditures associated with their sport. The primary alternative to lead shot is steel (iron) shot for shotgun cartridges. This is the most cost-effective alternative for lead shot and is currently the most widely used non-toxic shot for hunting migratory birds. The primary alternatives for lead-based bullets for hunting are 100% copper bullets or copper-zinc alloy bullets (90% copper). A range of other lead-free alternatives also exist and include tungsten-based shot and bismuth-based shot. Currently available lead-free alternatives can have equivalent performance to traditional lead ammunition, are non-toxic compared to lead shot, and the increased costs associated with the alternatives are minimal when compared to overall annual expenditures of hunters and sport shooters on their sports.

Exposure to lead from its uses in ammunition is a concern both for wildlife toxicity and human health and the scientific evidence supporting prohibition of this use of lead is strong (Arnemo *et al*., 2016). This has led to complete bans on lead ammunition in Denmark, The Netherlands, Sweden and California (phased in approach complete by 2019). Strong opposition on any regulatory action on ammunition from politically influential hunting/shooting lobby groups is the primary reason why restrictions on lead ammunition in other jurisdictions have stalled, been prevented, and in some cases, have even been repealed.

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Appendices

Appendix 1

Consolidated Importers List

The terms of reference for this study request the following details for major importers of ammunition: Details on company revenues, number of employees, distribution by province, and types and quantities of ammunition imported. The following table summarizes available data on these aspects for the major importers. Importers are listed in alphabetic order.

The following Table provides a consolidated summary of the major ammunition importers identified via CID for the HS codes relevant to this study. The terms of reference for this study request details on company revenues, number of employees, distribution by province, and types and quantities of ammunition imported. The following table summarizes available data on these aspects for the major importers.

Table 15. Consolidated Summary of Major Importers (Alphabetical order)

Company Name	Number Employees	Gross Annual Revenue	Province	Shotgun cartridges (930621)	Cartridges nes & parts thereof (930630)	Air gun pellets (930629)	Notes
CANADIAN TIRE CORPORATION, LIMITED [Retailer]	27,772	$12,462 mill	ON			P	500 stores across Canada. Brands sold include US mfrd Federal Premium: https://www.federalpremium.com/company/about_us.aspx, Crosman etc.
CROSMAN CORPORATION [US-based Manufacturer]	323	$11.7 mill	NY, USA			P	"Crosman Corporation, the world's largest designer and manufacturer of airguns and ammunition" Crosman is lead ammo mfr e.g. : lead airgun pellets http://www.crosman.com/airguns/airgun-ammunition/premier-22-piranha-hollowpoint-pellets
GENERAL DYNAMICS ORDNANCE AND TACTICAL SYSTEMS - CANADA INC. [Manufacturer]	1450	>$50 mill	QC		P		Seem to be mainly focused on military/defence - but mention non-military uses on website " GD-OTS Canada Valleyfield is specialized in the development and manufacture of sophisticated and advanced energetic materials for the both military and non-military markets. GD-OTS Canada Valleyfield has developed a family of products recognized worldwide for their consistency, performance and value. The company offers a complete line of single, double and triple based propellants for military and sporting applications," Major supplier to DND
HILTI (CANADA) CORPORATION [Sell Power Device Cartridges to Construction Industry]	70	$25 mill to $50 mill	ON		P		Cartridges are power device cartridges that do not contain a projectile, lead or otherwise. Used for firing nails into concrete. Therefore not relevant to this study. (Jerry Metcalfe (Health, Env., and Safety Contact)). Not included in any further analysis.
KENT CARTRIDGE CANADA INC [US-based Manufacturer]	4 (in Canada)	~$1 mill sales in Canada (Kent-Gambore total sales $3.27 mill)	ON	P			Import both shotgun cartridges containing lead and steel shot. Re-introduced bismuth in 2016. Majority of imports are lead.

KORTH GROUP LTD. [Distributor]	20	$3 mill	AB		P		Imports Hornady and Federal Ammunition brands. Delivers ammunition to retail stores. Imports are 90% lead. Volume of ammunition imports has increased over last 5 years.
NORTH SYLVA CO DIVISION OF PARKLANDS MANOR INC [Distributor]	12	$2.3 mill	ON	P	P		$65,000 in sales to Ontario Ministry of Community Safety and Correctional Services: http://www.fin.gov.on.ca/en/budget/paccts/2015/15_vol3_MCSCS.html / note that North Sylva is listed as only 'partner' in Canada for Sellior & Bellot (CZ-based mfr)
OLIN CHLOR ALKALI PRODUCTS AND VINYLS [Industrial Div. of US-based Ammunition Manufacturer] Olin Canada ULC (Div. of Olin Corporation)	350	$1.7 bill (Olin Corp)	QC	P	P		Chlor Alkali products only manufactured at this site - Olin Corporation must use this facility as importer of record for some of their ammunition imports : https://www.olinchloralkali.com/en-us/Locations/Becancour-QC
OLIN CORPORATION WINCHESTER DIVISION [US-based Manufacturer]	3,773	$1.7 bill	IL, USA		P		Olin Corporation is a large MNE operating in various sectors. Ammunition manufacturing (Winchester Div) is just one of the sectors this corporation is active in.
REDL SPORTS (Maurice Sporting Goods) [Distributor]	29-50	$9.24 mill	BC	P			Importer address of record is US. Company has Canadian distribution centre in BC. BCDC (British Columbia Distribution Centre) boasts 75,000 square feet including 5,000 square feet of office space. Distribution leader Maurice Sporting Goods acquired Redl Sports in 2011, and plans were immediately put in place to grow and expand the sister company as part of Maurice's long-term commitment to the Canadian marketplace. Retailers for REDL Sports products listed here: https://www.redlsports.com/retailers.html
PRAIRIE SHOT LTD. [Canadian Manufacturer]	1-4	<$800,000	MB			P	Company website states that it manufactures cartridges in Canada.

REMINGTON ARMS COMPANY INC [US-based Manufacturer]	2275	$670.4 mill	NC, USA	P	P		Remington Outdoor (formerly known as 'the Freedom Group') owns multiple ammunition brands and ammunition manufacturing facilities based in the US including Remington Arms. Annual sales are for Remington Arms Company. https://www.remington.com/ammunition
GRAVEL AGENCY INC. [Distributor for Remington]	51-200		QC				Gravel Agency Inc. is a company specialized in commercial representation known across Canada within the hunting and fishing industry. Represents Remington in Canada.
SOCIETE D'EXPANSION COMMERCIALE LIBEC INC (Challenger Ammunition) [Manufacturer]	15	$6.71 million for S.E.C. Libec Inc.	QC			P	Challenger Ammunition Imports - company name 'S.E.C.L (Libec) Inc (Challenger Ammunition / Imperial Ammunition)'
S.I.R. MAIL ORDER = CABELA'S [Retailer] Cabela's Canada (bought by Bass Pro Oct 2016)	19,700	$3 bill	MB	P	P	P	Cabelas is headquarted in Winnipeg MB and has 12 large stores in Canada with plans to open more: In BC (2), AB (3), SK (2), MB (1), ON (2), NB (1), NS (1 planned: opening in 2018). Bass Pro (which purchased Cabelas in October 2016) has 3 larges stores in Canada: BC, AB and NB. Note SIR Mail Order bought by Cabelas in 2007, www.sirmailorder.ca directs to www.cabelas.ca
TARGET CATTLE CONCEPTS [Sells blank cartridges for drug delivery]	n/a	n/a	SK			P	Distributor of Pneu-dart - cartridge-fired drug delivery - cartridge made by CCI and not relevant to this study: http://www.pneudart.com/products/darts/darts-types/ Not included in any further analysis.

Appendix 2

Hunter Survey (2017): The electronic survey was sent out by email using SurveyMonkey[261] under Toxecology's professional survey subscription and responses were protected with SSL encryption. Responses were received from 520 hunters/shooters. Not all respondents answered all the questions. More than 95% of responses were from BC, with remaining responses received from Alberta, Manitoba, Saskatchewan and the Yukon. Although other hunting / wildlife associations and federations across Canada were sent the survey, the BCWF was the most effective in distributing the survey to their members.

Lead Ammunition in Canada - Survey for Hunters - Study for Environment and Climate Change Canada

Study Background and Questions

Environment and Climate Change Canada requires information on the uses of lead ammunition in Canada. Lead is associated with risks to human health and the environment. A State of the Science report published by Health Canada in 2013 indicated that there were no safe blood lead levels for neurotoxicity. There is a growing awareness that significant lead exposure can occur from eating game meat contaminated with lead ammunition fragments. In addition, there are concerns regarding potential for wildlife toxicity.

The overall objective of this study is to gather information on current uses of lead ammunition in Canada using a wide variety of different sources. The purpose of this survey form is to gather information directly from hunters in Canada to ensure the perspectives and experience of hunters is captured by the study.

Toxecology – Environmental Consulting Ltd has been retained by the Federal Government to gather the required information. If you have any questions regarding the survey please contact Dr. Pamela Campbell (604) 899-3388; Email: Campbell_pm@telus.net. Your participation in this survey is important. The data you provide via this survey is secure – it will transmitted securely by Fluid Surveys/Survey Monkey directly to Dr. P.M. Campbell only and will be protected as confidential business information. You may also choose to return this survey anonymously – just do not give your name on the form – but we do request you provide us with some details on your uses of ammunition and your location (Province) so that we can combine responses appropriately in the analysis. We recognize that you are busy and appreciate you taking the time to complete this survey – as a small token of appreciation we will enter your name into a draw for a $100 gift card for Chapters/Indigo. If you wish to be entered into the draw your response to this survey must be returned by the deadline of January 31st, 2017. In order to be entered into the draw you must also complete the last question - this contact information will only be used if you win the draw so that we can get the gift card to you, it will not be used for any other purpose.

[261] https://www.surveymonkey.com

1. Where do you live?

- ◯ Ontario
- ◯ Quebec
- ◯ Alberta
- ◯ British Columbia
- ◯ Manitoba
- ◯ Saskatchewan
- ◯ Newfoundland and Labrador
- ◯ New Brunswick
- ◯ Nova Scotia
- ◯ Yukon
- ◯ Northwest Territories
- ◯ Nunavut
- ◯ Prince Edward Island

2. Where do you usually hunt? (You can tick multiple locations if relevant)

- ◯ Ontario
- ◯ Quebec
- ◯ Alberta
- ◯ British Columbia
- ◯ Manitoba
- ◯ Saskatchewan
- ◯ Newfoundland and Labrador
- ◯ New Brunswick
- ◯ Nova Scotia
- ◯ Yukon
- ◯ Northwest Territories
- ◯ Nunavut
- ◯ Prince Edward Island

3. What activities using ammunition do you participate in each year? Select all that apply.

- [ ] Hunting - waterfowl (and other bird species requiring lead-free ammunition)
- [ ] Hunting - birds (excluding those requiring lead-free ammunition)
- [ ] Hunting - small game
- [ ] Hunting - large game
- [ ] Shooting - outdoor target shooting
- [ ] Shooting - trap/skeet shooting
- [ ] Shooting - sporting clay
- [ ] Shooting - indoor
- [ ] Other (please specify)

4. What type and size of ammunition do you typically use for each activity? Please specify if the ammunition you use is lead or non-lead e.g. Shooting - trap/skeet shooting: '12 gauge lead shotgun shells'

Hunting - waterfowl:	
Hunting - birds (excluding waterfowl):	
Hunting - small game:	
Hunting - large game:	
Shooting - outdoor target shooting:	
Shooting - trap/skeet shooting:	
Shooting - sporting clay shooting:	
Shooting - indoor:	
Other (please specify):	

5. In the last 12 months how many rounds/shots did you discharge for each activity you participated in? An estimated range is fine e.g. Shooting - trap/skeet: '300-400 rounds'

Hunting - waterfowl:	
Hunting - birds (excluding waterfowl)	
Hunting - small game:	
Hunting - large game:	
Shooting - outdoor target shooting:	
Shooting - trap/skeet shooting:	
Shooting - sporting clay shooting:	
Shooting - indoor:	
Other (please specify):	

6. Where do you buy your ammunition from? (select all that apply)

- [ ] Large retailer
- [ ] Local outfitter/shop
- [ ] Directly from an individual that comes to my shooting range/club with ammunition supplies
- [ ] Online
- [ ] I reload my own cartridges
- [ ] I send my empty cases to a company that reloads/remanufactures cartridges and they reload them for me
- [ ] Other (please specify)

7. Please describe your experience with non-lead ammunition in the text box below (e.g. Is it available for you to buy where you usually buy your ammunition? What is your experience with non-lead ammunition performance, price, and any other factors you feel are relevant? If you haven't tried non-lead ammunition - please state this below)

8. If you have any other comments you would like to add please provide these below.

Lead Ammunition in Canada - Survey for Hunters - Study for Environment and Climate Change Canada

Optional information to enter draw for $100 Chapters/Indigo gift card

9. If you would like to be entered into the draw for the gift card - please provide your name and email below (optional)

Name:

Email:

Appendix 3

Non-Toxic Ammunition Approved by California

Certified Nonlead Ammunition

- Shotgun ammunition containing pellets composed of materials approved as nontoxic by the U. S. Fish and Wildlife Service, as identified in Section 507.1 (Title 14, CCR) is considered certified. **NOTE: The U.S. Fish and Wildlife Service may review and approve applications for other types of non-toxic shot throughout the year** -- **See the full list of approved shot types**.
- While the Department has certified various nonlead alternative projectiles for hunting with firearms, big game may only be taken by rifles using centerfire cartridges with softnose or expanding projectiles. Projectiles designed as frangible (disintegrating) or fractional (separates into distinct parts) are not a legal method of take for big game species (as defined in Sections 350, 353 and 475(c), T14, CCR).
- The following table lists currently certified non-lead ammunition (choose a link to go to the manufacturer's current information). This certified list will be updated as new applications are received and approved.

Name	Date Application Received	Date Application Approved
Ammo Brothers (PDF)	September 22, 2008	September 25, 2008
Barnes Bullets, Inc. (PDF)	April 16, 2008	April 28, 2008
Bishop Ammunition Manufacturing (PDF)	August 18, 2011	October 11, 2011
Black Hills Ammunition (PDF)	June 10, 2008	July 2, 2008
Blackstone Ammunition (PDF)	October 9, 2014	October 21, 2014
California Republic Bullets (PDF)	June 26, 2015	June 30, 2015
CCI - Speer (PDF)	April 15, 2008	April 28, 2008
Cutting Edge Bullets (PDF)	February 26, 2010	October 21, 2015 (rev.)
Custom Cartridge, Inc. (PDF)	March 14, 2008	April 28, 2008
Dakota Ammo (COR-BON/Glaser) (PDF)	April 16, 2008	April 28, 2008

D Dupleks Ltd. (PDF)	March 2, 2010	March 16, 2010
Dynamic Research Technologies (DRT) (PDF)	July 29, 2009	September 8, 2009
Federal Premium Ammunition (PDF)	April 15, 2008	April 28, 2008
G2 Research, Inc. (PDF)	April 9, 2015	April 21, 2015
GS Custom Bullets LLC (PDF)	January 14, 2012	February 2, 2012
James Gilmore (PDF)	November 24, 2015	January 14, 2016
Hasler Bullets (PDF)	August 20, 2015	October 14, 2015
HD Custom Rifles and Ammunition, LLC (HammerBullets) (PDF)	March 25, 2016	April 28, 2016
Hornady Mfg. Co (PDF)	December 8, 2008	December 29, 2008
HPR Ammunition (PDF)	September 23, 2014	September 30, 2014
International Cartridge Company (PDF)	August 12, 2008	September 4, 2008
Lehigh Defense, LLC (PDF)	June 10, 2014	July 29, 2014
Liberty Ammunition, Inc. (PDF)	September 9, 2013	October 22, 2013
Magtech Ammunition Company (PDF)	September 11, 2008	October 20, 2008
McGuire Grinding (PDF)	April 17, 2015	April 30, 2015
Miwall Corporation (PDF)	September 23, 2008	October 20, 2008
Monolithic Munitions LLC (PDF)	January 14, 2012	February 2, 2012
Nammo Lapua Oy (PDF)	July 31, 2012	September 5, 2012

North Fork Bullets (PDF)	January, 27 2009	February 23, 2009
Nosler, Inc. (PDF)	March 25, 2008	April 28, 2008
OATH Corporation (PDF)	October 20, 2015	November 23, 2015
OPG Gun Ventures, LLC (PDF)	June 11, 2012	June 25, 2012
P-Bar Co., LLC (PDF)	November 30, 2009	January 4, 2010
PolyCase Ammunition, LLC (PDF)	January 09, 2015	February 2, 2015
Remington Arms Co., LLC (PDF)	March 25, 2008	April 28, 2008
Sig Sauer (PDF)	January 13, 2016	April 28, 2016
Sinterfire, Inc (PDF)	May 29, 2008	July 2, 2008
Sellier & Bellot (PDF)	May 31, 2013	July 22, 2013
Snake River Ammunition (PDF)	August 31, 2009	September 14, 2009
Solid Copper Bullet (PDF)	August 18, 2014	October 10, 2014
Stars & Stripes Ammunition (PDF)	August 15, 2008	September 11, 2008
Styria Arms (PDF)	February 10, 2011	March 1, 2011
TomBob Outdoors, LLC (PDF)	March 15, 2010	April 21, 2010
Velocity Tactics (PDF)	January 19, 2016	January 25, 2016
Weatherby, Inc. (PDF)	May 29, 2008	July 2, 2008
Winchester Ammunition (PDF)	April 7, 2008	April 28, 2008

Wildlife Branch - Game Management
1812 9th Street, Sacramento, CA 95811
(916) 445-0411

Source: https://www.wildlife.ca.gov/Hunting/Nonlead-Ammunition/Certified

Appendix 4

Historical Perspective on International Lead Ammunition Regulation to 2008 (Avery and Watson, 2009) – refer to relevant updates 2008 to 2017 in report text (see section 5)

Table 1. Comparison of types of lead-based ammunition regulation worldwide in 2008.
Asterisk indicates states or other sub-regions of countries.

Country or State	Recommended use of nontoxic shot	Partial ban on lead shot	Ban on lead shot in wetlands or for waterfowl	Ban on lead shot for all hunting	Partial ban on lead ammunition	Ban on all forms of lead ammunition	Ban on hunting	Nontoxic shot regulations in addition to Federal
Austria	Banned prior to 2002							
Australia								
*Capital Territory, AU							Hunting ban on native wildlife	
*Western Australia, AU							Hunting ban on duck and quail	
*South Australia, AU		Banned during duck season, 1998		1993				
*Northern Territory, AU		Banned in hunting reserves, 1998						
*Queensland, AU	2001	Banned at three sites					Hunting ban on duck and quail, 2005	
*Tasmania, AU			2004					
*New South Wales, AU		Ban for duck hunting					Hunting ban on duck	
*Victoria, AU		Banned for duck hunting, 1993	1995					
Denmark	1985		1993	1996		Ban on the import of lead ammunition, 2000		
Belgium		Banned in Ramsar sites, 1993	1998	Ban considered for 2008				
Canada			1997	1999 lead shot banned for hunting game birds				

Country or State	Recommended use of nontoxic shot	Partial ban on lead shot	Ban on lead shot in wetlands or for waterfowl	Ban on lead shot for all hunting	Partial ban on lead ammunition	Ban on all forms of lead ammunition	Ban on hunting	Nontoxic shot regulations in addition to Federal
Cyprus			1993					
Finland			1996					
France			2006					
Germany	1993	Ban in 10 states						
Ghana							Hunting ban in wetlands and irrigation sites	
Hungary			2005					
India							All hunting banned	
Israel							Most wetlands closed to hunting– must use lead shot	
Italy			Proposed date unknown					
Japan					Partial ban on lead ammunition for deer, 2000			
Kenya								
Latvia		Banned in wetland SPA's, 2000						
Liberia			Military coup banned lead shot, 1980					
Malaysia		Date unknown						
Malta		Banned in two wetlands						

Country or State	Recommended use of nontoxic shot	Partial ban on lead shot	Ban on lead shot in wetlands or for waterfowl	Ban on lead shot for all hunting	Partial ban on lead ammunition	Ban on all forms of lead ammunition	Ban on hunting	Nontoxic shot regulations in addition to Federal
Mauritania						Ban on all lead for large game and sport hunting 1975		
Netherlands				1993	Banned for clay pigeon shooting, 2004			
Norway			1991	2005				
Poland	Recommended							
Portugal			Proposed for 2008					
Russia		Some restrictions for wetlands						
South Africa		Partial ban on lead shot for waterfowl						
Spain		Banned in Ramsar sites in 1994	2001					
Sweden			2002		Banned for clay pigeon shooting, 2002	2008		
Switzerland			1998					
Great Britain								
*England		Voluntary ban in 1995	1999					
*Scotland			2005					
*Wales		Banned in SSSI wetlands 2002						
New Zealand		10 or 12 gauge shot banned, 2006						
United States			1991					
*Tejon Ranch, CA						2008		
*Camp Roberts, CA						2007		
*Alabama								

Country or State	Recommended use of nontoxic shot	Partial ban on lead shot	Ban on lead shot in wetlands or for waterfowl	Ban on lead shot for all hunting	Partial ban on lead ammunition	Ban on all forms of lead ammunition	Ban on hunting	Nontoxic shot regulations in addition to Federal
*Alaska								Yes
*Arizona								
*Arkansas								
*California					Banned in Condor range 2008			Yes
*Colorado								
*Connecticut								
*Delaware								
*Florida								
*Georgia								
*Hawaii								
*Idaho								
*Illinois								Yes
*Indiana								
*Iowa								Yes
*Kansas								Yes
*Kentucky								Yes
*Louisiana								Yes
*Maine								Yes
*Maryland								Yes
*Massachusetts								Yes
*Michigan								Yes
*Minnesota								Yes
*Mississippi								
*Missouri								Yes
*Montana								
*Nebraska								Yes
*Nevada								
*New Hampshire								

Country or State	Recommended use of nontoxic shot	Partial ban on lead shot	Ban on lead shot in wetlands or for waterfowl	Ban on lead shot for all hunting	Partial ban on lead ammunition	Ban on all forms of lead ammunition	Ban on hunting	Nontoxic shot regulations in addition to Federal
*New Jersey								Yes
*New Mexico								Yes
*New York								Yes
*North Carolina								Yes
*North Dakota								Yes
*Ohio								Yes
*Oklahoma								
*Oregon								Yes
*Pennsylvania								
*Rhode Island								
*South Carolina								
*South Dakota								Yes
*Tennessee								
*Texas								
*Utah								Yes
*Vermont								
*Virginia								
*Washington								Yes
*Wyoming								Yes

Table 2. Regulation of lead ammunition over time.

Date	Country and type of regulation
1975	Mauritania hunting laws prohibit use of toxic ammunition for large game and sport hunting.
1980	Liberia bans lead shot due to military coup.
1985	Denmark hunters initiate use of nontoxic shot.
1989	
1990	
1991	USA bans the use of lead shot over wetlands.
	Norway bans lead shot in wetlands for hunting of all ducks, geese, and waders.
1992	
1993	South Australia, Australia bans the use of lead shot.
	Victoria, Australia bans the use of lead shot during duck season.
	Denmark bans the use of lead shot over wetlands.
	Cyprus bans the use of lead shot over wetlands.
	Germany bans the use of lead shot over wetlands in 8 Lander and recommends voluntary use of nontoxic shot over all wetlands.
	Belgium bans the use of lead shot over Ramsar wetlands.
	February-Netherlands bans the use of lead shot for hunting over wetlands.
1994	
1995	Victoria, Australia bans the use of lead shot for duck hunting.
	Netherlands bans the use of lead shot in all hunting.
	UK instills voluntary use of nontoxic shot over wetlands.
1996	Denmark bans the use of lead shot in all hunting.
	Finland bans the use of lead shot over wetlands.
1997	Canada bans the use of lead shot for hunting migratory game birds near water.
1998	Switzerland bans the use of lead shot for hunting over wetlands and shallow water areas.
	Belgium bans the use of lead shot over all wetlands.
	Northern Territory, Australia bans the use of lead shot during duck season.
1999	England prohibits use of lead shot over wetlands and for all waterfowl.
	Canada bans the use of lead shot for hunting all migratory game birds (with a few exceptions).
2000	Japan bans the use of lead bullets for deer hunting in Hokkaido.
	Latvia bans the use of lead shot over wetland special protected areas.
	Spain bans the use of lead shot at Ramsar sites.
	Denmark bans the import of all lead products including ammunition.
2001	Queensland, Australia instills voluntary ban on the use of lead shot over wetlands.
	1 June-Spain bans the use of lead shot over all wetlands.
2002	Sweden bans the use of lead shot over wetlands.
	Wales bans the use of lead shot over wetland sites of special scientific interest.
	Sweden bans the use of lead shot for clay pigeons.
2003	
2004	Netherlands bans the use of lead shot for clay pigeons.
	Tasmania, Australia bans the use of lead shot over public wetlands and Crown Land.
2005	Hungary bans the use of lead shot over wetlands.
	31 March-Scotland bans the use of lead shot over wetlands.
	Norway bans the use of lead shot for all hunting.
2006	New Zealand bans 10 and 12 gauge shot for waterfowl near water.
	France bans the use of lead shot over wetlands.
2007	Camp Roberts, California, USA bans all lead ammunition for hunting.
	Fort Hunter Liggett, California, USA bans lead ammunition for hunting.
2008	Tejon Ranch, California, USA bans all lead ammunition for hunting.
	Camp Roberts, California, USA bans use of all lead shot and ammunition for hunting.
	California, USA bans the use of lead ammunition when taking big game and coyotes in the California Condor range in California.
	Sweden enacts a total ban on lead shot and ammunition.
	Belgium considers a total ban on the use of lead shot.
	Portugal proposes a ban on the use of lead shot in wetlands.

Source: Avery and Watson, 2009