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Executive summary

AFEMS is submitting this information in response to the call for evidence. It has collected information from its members in the context of the questions asked. Based on the analysis of the information collected, AFEMS would like to highlight that from the perspective of substitution, ammunition must be considered as a unit that has a performance that has been engineered for its intended use. This complexity is not captured in the call for evidence. While ammunition does generally contain a lead projectile, it is not simply a matter of replacing the projectile material with an alternative. The performance of a piece of ammunition comes for all of its components and it is engineered to have specific ballistic and impact properties. Considering solely the projectile discounts the reality that ammunition is a unit whose performance also depends on the specifications of the firearm used to discharge it. Changing any one component means that re-engineering is necessary. AFEMS requests that ECHA consider carefully the information collected in terms its assessment of the technical and economic feasibility of alternatives for all ammunition types. The availability of alternatives for shotshell ammunition needs to be re-assessed considering the availability and sustainability of two proposed alternatives (Bismuth and tungsten). The time to re-engineer non-shot shell ammunition used for hunting needs to be considered to ensure that the new ammunition is as humane as the ammunition it is intended to replace. For sports shooting, the impact on the proposed restriction would be profound and essentially end competitive shooting as a sport in the EEA. A derogation is specifically requested for sports shooting from the scope of the restriction. For the use of lead ammunition in hunting, AFEMS requests that ECHA consider the time needed to design, develop and put on the market sufficient quantities to meet current demand. In addition while military use is outside the scope of the restriction, the implications on the security of supply of military ammunition needs to be considered if civilian supply lines cannot be used to increase supply in the event of a sudden increase in use (e.g. a conflict situation).

The key learnings from the socio-economic analysis undertaken was the large size and the complex characteristics of the industry, and that the proposed restriction would have severe negative socio-economic impacts on the ammunition manufacturers and the related European society. Annually the industry records a turnover of nearly 3 Billion euros and employs over 12 thousand employees. The proposed restriction would endanger all this and undoubtedly cease at least all the 8 uses presented in the analysis with annual monetary losses potentially up to **1 Billion euros** and over **5,000 jobs lost** in the EEA.

The format of the document follows Q3 and Q4 from the call for evidence For Q3, information was collected from AFEMS members via questionnaires specifically addressing the 6 points in the question. Two additional questions that were posed in the webinar were also addressed. A socio-economic analysis of the proposed restriction specifically on EEA based ammunition manufacturers was also undertaken in response to Q4. The information used in the socio-economic analysis was collected from AFEMS and its members via questionnaires.

The key learnings from the survey was that the proposed restriction impacts 100's of individual products. For each product, the technical and economic feasibility of a re-engineered lead free unit of ammunition would need to be considered. The production volume of lead-free products is insignificant compared to lead containing ammunition and for some ammunition types (rimfire bullets), none of the

responders reported that they offer a lead free equivalent. From the information collected, it is also clear that the approach of solely considering the projectile in terms of alternatives is overly simplistic. In terms of alternatives, the performance of the unit of ammunition as a whole needs to be considered.

Additional key points

Shotshells (gunshot): The availability and sustainability of the projectile raw material needs to be considered as two of the materials considered as suitable alternatives for lead shot in the wetlands dossier are on the 2017 list of critical raw materials. The availability of bismuth in particular is not sufficient to meet demands and its use in ammunition is not sustainable. Tungsten is also covered by the Conflict Mineral Regulation that comes into force in 2021 as is tin, another alternative that has approval as an alternative to lead. The sole alternative to lead is therefore limited to steel. Issues that were discounted in the wetlands dossier therefore need to be considered; specifically shooter safety with non-steel shot proofed shotguns, forestry damage (in regions that have a forestry industry), risk of ricochet and risk of forest fires due to sparking on hard surfaces.

"bullets": 100's of products would be scope of the restriction. The technical and economic feasibility of substitution would need to be considered separately for each unit of ammunition. For each product, the producer needs to optimize the propellant and the bullet in firearm to reach the best possible performance. The ability of alternatives to kill humanely would need to be ensured as it has been through decades of research & development for lead containing ammunition. The impact of the ban on sports shooting would be profound as it would mean the end of competitive shooting in the EEA with knock-on effects on shooting clubs and ranges.

Pellets: there are no alternative that have the same equivalent performance meaning that a ban would mean that sports shooters in the EEA would be non-competitive compared with shooters outside the EEA.

A derogation for sports shooting is requested together with the reasoning.

The potential impact on the **security of supply** of ammunition for defense is highlighted. There may be shortages in supply in crisis situations if civilian supply lines make different ammunition. Lead-free and lead containing ammunition have different machines/assembly lines meaning that the number of lines available for defense ammunition will be significantly reduced.

Summary of information collected

Information on the current production of lead containing and lead-free ammunition was collected from AFEMS members via questionnaires. The terminology used in the call for evidence was used and ammunition was differentiated into 3 broad types (i) shotshell ammunition (ii) non-shotshell ammunition (iii) pellets. For each type, the type of activity the ammunition is used for was collected; (i) hunting, (ii) sports shooting and (iii) non-civilian use. Pellets were considered separately as they do not have a cartridge and are fired with air rifles or pistols.

Non-shot shell ammunition are far more diverse compared to the quite simple shotshell ammunition and covers ammunition that can be fired with handguns, rifles, etc. for different purposes; sports shooting, security, defense, hunting, etc. For the purpose of this call for evidence, non-shotshell ammunition was differentiated by the firing mechanism (i) centerfire and (ii) rimfire. Note that these categories are very broad and each cover a diversity of products with different calibers, weights, lengths, jacketing, etc.. Ammunition manufacturers generally have a broad portfolio of products of each caliber, each made to specification for its ballistic performance. The eight types are given in Table 1.

The terminology used in the surveys circulated in given in Annex I.

In the next sections, answers to Q3 & Q4 are given as per the call for evidence.

Q3(i) Information on tonnages of lead shot, bullets and pellets placed on the EU market

The questionnaires collected information on tonnages for the 8 types of ammunition from AFEMS members. From those that provided this information (20 members), an extrapolation was done to estimate the tonnage for all AFEMS member. The methodology and values are given in the response to Q4 in this document.

Q3(ii) The identity of existing or emerging alternatives and any information on the existing market share of comparable products on the market that do not contain lead;

Table 1 compiles the information collected in the survey of ammunition manufacturers. Based on the call for evidence terminology, the various ammunition classes were broken down into eight broad categories of ammunition product types. The surveys collected information on the type of ammunition manufactured (or offered where ammunition was also imported), whether lead-free products were offered for the same ammunition type, the reported alternative projectile material, information on profitability and the lead-free production share as a % of total sales. This simplified approach was taken to get an understanding of the overall availability of alternatives. The same approach was used to collect socio-economic information used to prepare the response for Q4 of the call for evidence. Information on products offers for non-civilian users was also collected as many manufactures supply to both civilian and non-civilian users.

21 parties provided responses. 19 were ammunition manufacturers, 1 was a distributor and 1 was a lead refiner. 2 supplies solely for the military and did not provide any information. The remaining 17 manufacturers and 1 distributor had a range of product portfolios covering shotshell, rimfire and centerfire “bullet” and pellets. All offered more than one ammunition type. 9 solely offered shotshells for hunting and sports shooting, 1 offered shotshells and pellets, 1 offered solely rimfire for sports

shooting, 1 offered solely centerfire ammunition for hunting and military use. Pellets are offered by 3 of the responders. The remainder offered a range of products.

Table 2 gives an overview of information collected by ammunition type in the survey. The projectile material for the lead-free ammunition offered is also given. As many manufacturers have concerns that the price of ammunition to their customers is used as an indication of cost, information on whether the ammunition is sold for profit, at cost or below cost was also collected. For many of the ammunition types, manufacturers report that they sell at or below cost. Some reported that they sell for profit but with a lower profit margin compared with lead ammunition of the same type.

Use #	Ammunition type	Offered by	Lead-free products offered by	Reported projectile alternatives	Profit margin	Lead-free ammunition production share
1	**shotshells for hunting**	13	12	Steel, bismuth, tungsten	7 for profit 1 low margin 3 at cost 1 below cost	1 reported 0 6 reported between 0-5 % 3 reported 10-20 % 1 reported 20-30 %
2	**shotshells for sportshooting**	13	12	Steel, bismuth, tungsten	As for hunting	1 reported 0 6 reported between 0-5 % 1 reported 10-20 % 2 reported 20-30 % 1 reported 70-80 % * (importer)
3	**bullets for hunting (rimfire)**	2	0	-	-	-
4	**bullets for hunting (centerfire)**	5	5	Copper (5), Zinc alloy (1)	2 for profit 1 low margin 1 at cost 1 below cost	4 reported 0-5 % 1 reported 10-20 %
5	**bullets for sportshooting (rimfire)**	5	0	-	-	-
6	**bullets for sportshooting (centerfire)**	6	2	Copper (2), zinc alloy (1)	1 for profit 1 at cost	2 reported 0.1-0.25 %
7	**airpellets for hunting**	2	0	-	-	-
8	**airpellets for sportshooting**	3	1	Tin	Below cost	1 response 0.5 %
	bullets for non-civilian use (army, police, security) RIMFIRE	2	0	-	-	-
	bullets for non-civilian use (army,	6	3	Copper, zinc (2) Copper, steel (1)	2 for profit* 2 at cost	

	police, security) CENTERFIRE					

Table 1 Summary of the survey information by the 8 ammunition types for civilian use and 2 ammunition types for non-civilian use.

Many reported the units of ammunition offered by type. For lead ammunition, the responses ranged between 5-55 million units (shotshells for hunting), 0.5 to 80 million (shotshells for sports shooting), 4 - 12 million units (centerfire for hunting), 12 million (rimfire for hunting), 3 to 500 million (centerfire sports shooting), 10 to 200 million (rimfire for sports shooting), 5-10 million (pellets for sports shooting), 0-5 million (rimfire for non-civilian use) and 10-250 million (centerfire for non-civilian use). Using these numbers to estimate roughly the number of units of each type produced **across 20 responders** shows that for the responders, centerfire ammunition products are the most produced (ca. 1 billion units) followed by shotshell ammunition products (ca. 850 million units).

Table 2 gives the estimates for all the ammunition types as defined in the survey. Note that these figures are rough estimates based on information collected in a survey of a limited number of ammunition manufacturers where not all gave their production volumes. What is clear from the table is that none of the responders produce lead-free rimfire ammunition. The volumes of lead free centerfire ammunition is low for civilian use (ca. 0.5 million) but much higher for non-civilian use (ca. 60 million). However this is still only 10 % of the volume of lead containing centerfire ammunition for non-civilian use. Note the numbers are indicative as not all military suppliers reported their numbers and there are military suppliers who are not members of AFEMS. The overall percentage may be well below 10 %.

Use #	**Ammunition type**	**Estimate of total units of ammunition (millions)**	**Estimate of total units of lead-free ammunition (millions)**
1	**Shotshells for hunting**	350	20
2	**Shotshells for sports shooting**	500	40
3	**bullets for hunting (rimfire)**	10	0
4	**bullets for hunting (centerfire)**	50	0.2
5	**bullets for sports shooting (rimfire)**	350	0
6	**bullets for sports shooting (centerfire)**	850	0.35
7	**Pellets for sports shooting**	5-10	No values
8	**Pellets for hunting**	No values	No values
	bullets for non-civilian use (army, police, security) RIMFIRE	5	0
	bullets for non-civilian use (army, police, security) CENTERFIRE	650	60

Table 2 Estimates for the total units of lead containing and lead free ammunition of each type from the survey responses

Responders were also asked what would be needed to implement lead-free ammunition for each ammunition type. For rimfire ammunition, one responder outlined that their current premium lead ammunition was the result of 20+ years of continuous development and improvement.

One also gave the following outline of what would be needed to develop and implement alternative projectile materials into their complete product line of rimfire and centerfire ammunition. These are given in Table 3.

projectile	1. Establish non-lead material capable of delivering the same accuracy performance. 2. Design and build projectile manufacturing facility. 3. Establish procurement channel for necessary quantities of non-lead raw material. 4. Form working partnerships with target shooting firearms manufacturers to establish rifle characteristics that will enable accuracy capability 5. Develop new propellants as needed for ballistic performance 6. Assess requirements for projectile containment on shooting ranges, terminal energy dispersion and ricochet prevention. 7. Liaise with target shooting organisations to ensure all necessary range backstop modifications have been implemented. 8. Await availability of appropriate firearms in the market. We must finalize development types of projectiles, tools and machines and then to build up sufficient production capacity.
assembly of the projectile with the other components	New machineries, other propellants 1. Establish key loading process parameter specifications. 2. Implement all necessary propcess parameters.

Table 3 Extract from the survey response that gives steps that a responder said would be needed to develop and implement an alternative to lead containing rimfire ammunition

For shotshell ammunition, it was highlighted that steel shot would need to be purchased from new suppliers and that the current supply is 100 % dependent on imports from China. Many outlined that current supply would not be sufficient to meet the current production of lead shot. As many of the responders were shotshell ammunition manufacturers, many gave the steps they would need to take to change from lead to an alternative.

projectile	Steel shot will be purchased
assembly of the projectile with the other components	• Plastic free wad development, specific cases, specific powders for heavy loads, machinery adaptations, search of new and reliable suppliers • Remove existing equipment and invest in new one. Plastic free wad development, specific cases, specific powders for heavy loads, machinery adaptations, search of new and reliable suppliers. • Change or invest to adapt existing loading machines • Invest in new machinery and in bio-wads. New packaging. New suppliers for components and steel shots needed. • Development of new components for all product range (including new propellants)
	• Invest in 6 new machines
	• Wad typology will need to be modified. The company manufactures also plastic wads and all investments in moulds to stamp the plastic wad would be gone as they would need new moulds. Also they would need to modify all loading lines for steel shellshot production.

Table 4 Extract from the survey response that gives steps that a responder said would be needed to develop and implement an alternative to lead containing shot ammunition

Many of the responders highlighted that the survey did not capture that the manufacturing process for lead and non-lead projectiles is completely different meaning that completely different manufacturing lines would be needed for each non-lead alternative. Harder materials would need to machined and/or sintered. Lead (Pb) can be cold-pressed (swaged) to the desired shape with high precision meaning that machining or heating is not needed.

Many responders also provided comments in the free text field with their view on other impacts of Pb-free ammunition. Some extracts are given in

Table 5.

	Killing effect, ecotoxicology, weapon system compatibility, ricochet (safety issue), accuracy
centerfire & rimfire for hunting & sports shooting	Significantly higher production costs
	Animal suffering. Referring to weapon actually on the market functional is not guaranteed. Also significant increase of wear on weapon on market. Increase risk of ricochet.
	1. Higher energy costs (and CO2 emissions) to non-lead projectiles 2. Greater ricochet potential will increase the hazard to users and those nearby
Shotshells for hunting & sports shooting	Shotshells price will increase 2-10 times depending on the product range
	All steel shots will have to be imported from China -> an additional 1 M GBP in "transit goods" (shipping)
	Safety issues, ricochet, uncertainty regarding alternatives, "will not release undesired pollution items".

Table 5 examples of responses given in the free text field for "other impact of Pb-free ammunition"

The survey also collected information on products where manufacturers consider there is no alternative current available. Examples of the responses are given in

Table 6.

Shotshells	No alternatives for: • Small gauges • .410 • 65 mm cartridges • Cartridges with more than 36 grams
	No alternatives for long shot cartridges
rimfire	Smallbore rimfire 0.22LR used in small animal hunting and vermin control relies upon the unique mechanical and physical properties of lead to provide the rapid and efficient transfer of terminal energy required to ensure a humane kill.
	high accuracy target shooting projectiles for smallbore calibres (0.17 air and 0.22LR) rely upon the unique mechanical and physical properties of lead to ensure the essential criteria for both internal and external ballistics are achieved, thereby delivering the necessary precision at the target.

Table 6 examples of the responses given for products by ammunition type where it was considered that no alternative is available

Note on the survey

The survey also aimed to collect information on costs, alternatives and timelines. However, the survey responses showed that ammunition manufacturers struggled with how to provide answers using the terminology of the call for evidence. The terminology is a simplification of many different ammunition classes where the product portfolio can be in the 100's each with its own technical specifications and where it has been engineering for its ballistic performance in a firearm that is designed to discharge it. This complexity is not captured in the call for evidence. While ammunition does generally contain a lead projectile, it is not simply a matter of replacing the projectile material with an alternative. The performance of a piece of ammunition comes for all of its components and it is engineered to have specific ballistic and impact properties. The firearm, ammunition and propellant is a "technological continuum", Considering solely the projectile discounts the reality that ammunition is a unit whose performance also depends on the specifications of the firearm used to discharge it. Changing any one component means that re-engineering is necessary. Safety is also an issue. It is important that the projectile performs to specification so that the shooter, the general public are not at risk of injury from a poorly engineering unit of ammunition discharged from a firearm that was not designed for it.

A non-exhaustive list of ammunition calibers is given in **Annex II** for both shotshell and non-shotshell ammunition. For non-shotshell calibers, there can be 10's of products of the same caliber that differ in projectile weight, jacketing, velocity, projectile tip shape, etc.

A list of common rimfire and centerfire calibers is also given. A non-exhaustive list of the calibers used for hunting, sports shooting and non-civilian uses is also given. Finally a schematic showing the combination of products possible by ammunition class for three calibers. The same is given for shotshell ammunition.

Q3(iii) Technical and economic feasibility of potential alternatives, including information on product performance, price differences between lead containing products and alternatives, the number of affected products, expected costs and timelines for full-scale production of alternatives, etc.;

Alternatives to lead have been under development for decades and there are commercial alternatives to lead in some ammunition types, in particular shotshells. However for "bullet" type ammunition, the number of lead-free products currently available is insignificant when the entire product range is considered (the number of calibers and for each, various combinations of the weight of the projectile, jacketed/not jacketed, the velocity, the type of firearm). The product portfolio can be 100's of products each with its own set of technical specifications for its intended use. For example, one manufacturer offers more than 100 products covering 32 calibers. Another offers products in over 100 calibers. As can be seen from

Table 1 and

Table 2, many ammunition manufacturers currently offer a limited range of non-lead ammunition. These products are produced in low volumes and for many below cost, at cost or for profit with a lower profit margin compared with lead containing products. This is in particular the case for non-shellshot products.

Technical feasibility: it may be possible to design and engineer lead free ammunition for most of the current products available. It will be necessary to adapt internal and external ballistics to try to obtain the same or close to the same terminal effect. It could be considered to simply a matter of time and money. The question is rather how much time and how much money would be needed to completely transition all product lines. As can be seen from

Table 1 and

Table 2, for some types there are no commercial alternatives available (i.e. rimfire bullet ammunition). Technical feasibility would need to be considered for each and every current piece of ammunition and each redesigned and engineered to have the same performance. This will have to be undertaken in conjunction with firearms manufacturers as ammunition is engineered for the firearm that will discharge it and vice-versa. For some products, it may not be possible and they will disappear from the EEA market. The technical feasibility would need to consider the ballistic performance of the redesigned and re-engineered piece of ammunition in a firearm developed to discharge it. There are no current alternatives to most, if not all, rimfire "bullet" ammunition. For target shooting, there is no material that currently has the same ballistic performance as lead projectiles (low softening point, plasticity, density). For air pellets, there is no alternative that has the same ballistic performance. Target shooters in the EEA will be required to use ammunition with inferior performance compared to their non-EEA counterparts.

Economic feasibility: the number of affected products is in the 100's. The issue is also an EEA one meaning that manufacturers would need to consider their export market and decide if they will continue their lead ammunition lines and commit to having two distinct production lines. Note that lead projectiles can be cold pressed to simple shapes or swaged to the shape required. This is not possible for non-lead projectiles and new manufacturing lines are needed. Manufacturers who supply to both civilian and non-civilian customers will also need to consider if their non-civilian line is sufficiently profitable to justify continuing supply of non-lead ammunition. The manufacture of the projectile for

non-shell ammunition is completely different for non-lead materials as machining and sintering are needed to shape the projectile. Manufacturers will need to invest in new equipment. The machines for assembly will need to be adjusted for the different specifications for the redesigned pieces of ammunition. This would need to be done on a massive scale to meet current demand for lead containing ammunition. For example, 6 manufacturers currently have a summed production volume of 1 billion units of centerfire bullet ammunition covering 100's of different products. Copper and Zn alloys are listed as the alternatives for the lead-free ammunition centerfire ammunition that is commercially available. Copper as a raw material is more costly. Each copper projectile will need to be precision machined meaning that more sophisticated machinery will be needed and massively in parallel to meet the supply needs.

Note that the widely cited 2019 California ban on the use of lead ammunition for hunting (Assembly Bill 711[1]) solely covers hunting. Pellets are not within scope as air guns are not firearms according to California law. Sports shooting is not within scope and the impact assessment conducted concluded the following relating to the impact on ammunition manufacturers;

> "*Steady growth in the target shooting market is expected to mitigate any shifts in hunting equipment sales. Lead ammunition supplies are expected to continue to be in strong demand by target shooters*"

This means that the increasing demand from sports shooting was considered to offset the impact on increased costs associated with lead-free products for hunting.

The economic feasibility would also need to consider the availability of the raw materials. This is in particular an issue for Bismuth (Bi) and Tungsten (W). This is considered separately in the next section.

Price differences: Relating to price differences, as can be seen from

Table 1, many of the manufacturers offer alternatives at below cost, at cost, or for a lower profit margin. They do so to be able to offer a full range of products to customers who want to or are required to use lead-free ammunition. It is important to note that the prices given on manufacturer or distributor webpages or brochures may not reflect the cost of manufacture or the profitability of the product.

Number of products: As outlined above, the number of products concerned is in the 1000's and each would need to redesigned, re-engineered if any one of the components was changed. Changing the projectile will mean a complete redesign of the piece of ammunition.

Timelines to full scale production: the production capacity currently for lead –free ammunition is limited and covers a limited number of 100's of products. In particular for "bullets", the timescale would critically depend on what level of re-engineering of both the unit of ammunition and the firearm are needed to get the same ballistic performance for the intended use. Lead projectiles have been developed and perform to specifications. This has taken years of research and development to reach today's performance and this development is ongoing to continually improve performance. A limited number of lead-free units of ammunition have been developed and this has taken years of research and development. In addition, If any change in C.I.P. standard is needed, it will take many years and it may

[1] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB711

well be permanently stopped by a veto from any single C.I.P. member state – including Russia, Chile and UAE who are not members of the EEA.[2]

[2] The "Permanent International Commission for the Proof of Small Arms" (C.I.P.) lays down common rules and regulations for the proof of weapons and their ammunition in order to ensure the mutual recognition of Proof Marks by its member states. Fourteen countries are C.I.P. Member States. The EU members are Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Slovakia, Spain and the United Kingdom. Non-EU members are Chile, Russia and United Arab Emirates. The C.I.P. safeguards that all firearms and ammunition sold to civilian purchasers in member states are safe for the users. The members recognise each other's Proof Marks and to implement C.I.P. Decisions in legal form (decree, ministerial order, law, etc.).
Firms wishing to manufacture, to market, or to import small arms ammunition within the C.I.P., must apply for C.I.P. Type Approval (Homologation). Only those firms that have been granted C.I.P. Type Approval can manufacture and market ammunition for weapons with either smooth bore or rifled barrels. Once Type Approved, the manufacturer must repeat the inspection and check tests for each new batch of manufacture. A Certificate of Conformity is to be issued for each calibre provided that the C.I.P. Standards have been met. An inspection mark (Proof Mark of the Proof House) is to be affixed to each box of ammunition. For more information, see https://www.cip-bobp.org/en

Q3(iv) Availability of alternatives in sufficient quantities on the market: current and future trends;

In terms of availability of raw materials used for the projectiles in both shotshell and non-shotshell ammunition, EU critical raw materials and materials subject to due diligence requirements need to be considered.

Two of the alternatives to lead that are used in both shotshell ammunition (**Bismuth** and **tungsten**) and non-shell ammunition (**tungsten**) are on the 2017 EU critical raw materials list[3]. In the wetlands restriction report, this availability/sustainability issue was not considered. Table 7 shows the main global producers, the main importer to the EU, the import reliance rate, the substitution indices and the end of life recycling rates taken from the Commission Communication to European Parliament on critical raw materials.[4] The key parameter is the substitution index. The 'Substitution index' is a measure of the difficulty in substituting the material, scored and weighted across all applications, calculated separately for both Economic Importance and Supply Risk parameters. Values are between 0 and 1, with 1 being the least substitutable. Both have values close to 1. The current supply of both raw materials is already considered to be critical and the end of life recycling rate is only 1 % for Bismuth. This means that current supply depends on primary sources, as there is no secondary sources from scrap. Further 50-60 % of Bismuth metal is extracted as a by-product in Lead metal refining from lead ores according to the critical raw material factsheet.[5] This means that the supply of bismuth is co-dependent on the market of lead. If there is no market for lead metal, it will not be refined meaning that by-products will also not refined. This has been discussed in detail in a 2013 UNEP report[6] on metal recycling and the key role that metals such as Pb play in metallurgy.

Both are also proposed as general replacements of lead in other uses such as radiation shielding (both Bi and W), counterweights (W), an alloying element in machinable brass (Bi). The relevance of the sustainability of alternatives is more easily explained from the perspective of current tonnages for a given use. The current tonnage of Pb metal used in **Ordnance** is reported as being **62,000 tons**[7]. Bismuth is proposed as an alternative to Pb in ammunition and is on the approved list of non-toxic materials in both the US[8] and California (Assembly Bill 7119) for use in ammunition (shotgun and rifle ammunition). Assuming that ca. 5 % of Pb ammunition will be substituted with Bismuth, this would require ca. 3000 tons. Next, we consider machinable alloys (steel and brass) where Pb is added at low amounts to

[3] Study on the review of the list of critical raw materials, Final report – Study, 2017 available at https://op.europa.eu/en/publication-detail/-/publication/08fdab5f-9766-11e7-b92d-01aa75ed71a1

[4] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on the 2017 list of Critical Raw Materials for the EU available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0490

[5] Study on the review of the list of critical raw materials, Critical raw materials factsheets, 2017, available at https://op.europa.eu/s/nCm9

[6] UNEP (2013) Metal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International Resource Panel. Reuter et al. (http://www.resourcepanel.org/reports/metal-recycling

[7] Annex XV report PROPOSAL FOR IDENTIFICATION OF A SUBSTANCE OF VERY HIGH CONCERNON THE BASIS OF THE CRITERIA SET OUT IN REACH ARTICLE 57 for Lead metal available at https://echa.europa.eu/documents/10162/17c3801f-ee57-de3b-cd02-cb39d15a80b3

[8] Nontoxic Shot Regulations for Hunting Waterfowl and Coots" regulation List of approved non-toxic material available at https://www.fws.gov/birds/bird-enthusiasts/hunting/nontoxic.php.

[9] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB711

facilitate machining. The alternative proposed is also Bismuth. Based on a report prepared by ILA[10],the volume of Pb used in leaded steel can be very high "*European leaded steel production figures are quoted as well over 1 million tonnes per year, containing **2000 tonnes of lead** (late 1990s), with British Steel alone producing half a million tonnes in 1997. (EUROFER, 1998)".* Information from position papers prepared by the Copper Institute in 2018 report[11], "*1,426 million tons of copper (source IWCC) were used in the EU to produce lead containing copper alloys. These are valued at 7.6 billion Euros*." Lead copper alloys can contain up to 3 % Pb. Taking a low value of 0.3 % for the lead content in leaded brass, this would require ca. **4000 tons** based on the numbers reported by the copper institute. Summing these numbers 3000 + 2000 + 4000 = **9000 tons**. This means the alternative needs to be available at high tonnage. It may be technically feasible (the renewal of exemptions under RoSH and ELV Directives imply that performance issues remain). However the current registered tonnage of Bismuth is **1000 – 10, 000 tons.** The current consumption reported in the Bismuth factsheet for the 2017 EU critical raw material list is 9000 tons meaning there is no production capacity for substitution. Any further substitution would massively increase demand. Supply would also decrease as 40-60 % of current supply comes from the metallurgical refining of Pb ores. If there is no market for Pb metal, the ores are not refined and the supply of Bismuth decreases. The end of life recycling rate reported in factsheet is 1 % meaning that current supply is entirely dependent on primary sources.

This example with Bismuth demonstrates shows that while Bi may be a technically feasible to lead in shotshell ammunition, it is not sustainable and its supply has complex interdependencies in its refining and recovery.

Tungsten and alloys based on tungsten are on the approved list of non-toxic materials in both the US and California (Assembly Bill 711[12]) for use in ammunition (shotgun and rifle ammunition). However, as outlined above tungsten metal is also on the 2017 Commission list of critical raw materials for the EU. The current demand reported in the Factsheet is 19,500 tons while the registration tonnage band reported on the ECHA website is 10,000-100,000 tons. The end-of-life recycling rate reported in the Factsheet is 42 %. The EU import reliance is less that for Bi (44 % vs. 100 %). However, W used in ammunition is generally not recoverable meaning that its use is a "drain" on the supply chain. Substitution of lead with W will increase the supply risk Tungsten. An additional supply consideration is that W is one of four **conflict minerals targeted by the EU Conflict Minerals Regulation**. The Regulation (EU) 2017/821[13] of the European Parliament and of the Council sets up a Union system for supply chain due diligence self-certification in order to curtail opportunities for armed groups and unlawful security forces to trade in tin, tantalum and tungsten, their ores, and gold. It will take effect on 1 January 2021. It is designed to provide transparency and certainty as regards the supply practices of importers, (notably smelters and refiners) sourcing from conflict-affected and high-risk areas. The EU regulation covers **tin**, **tantalum**, **tungsten**, and **gold** because these are the four metals that are most mined in areas affected by conflict or in mines that rely on forced labour. The regulation only applies directly to EU-based

[10] ILA, International Lead Association(2001c).Lead the facts. Prepared by IC Consultants Ltd, London, UK. Chapter 3. Applications of lead. Available at: https://www.ila-lead.org/UserFiles/File/factbook/chapter3.pdf

[11] Katrien Delbeke, John Schonenberger and Laia Perez Simbor, European Copper Institute, updated January 2014; COMMENTS ON THE CLASSIFICATION PROPOSAL: LEAD TO BE CLASSIFIED AS REPRODUCTVE TOXICANT (SCL 0.03%),

[12] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB711

[13] REGULATION (EU) 2017/821 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0821

importers of tin, tantalum, tungsten and gold, whether these are in the form of mineral ores, concentrates or processed metals. Substitution of Pb with W will increase demand and further increase the due diligence requirements that the increased supply needed to fulfil the demand is not coming from conflict regions.

According to the EU critical raw material factsheet, **Tungsten is an important metal with no substitutes**, and a key component in steel manufacturing, construction, oil drilling, and mining industries. It is also used in the fabrication of wires and filaments used in electrical, heating, and lighting applications. Due to its hardness and high density, it is used in military applications in penetrating projectiles. The factsheet concludes that **tungsten is not really replaceable in the majority of the applications because it offers the best compromise between exceptional performance and price**.

In summary, the use of both Bi and W in ammunition is not a sustainable use of these two critical raw materials.

Tin: Tin and alloys based on tin are the approved list of non-toxic materials in both the US and California (Assembly Bill 711) for use in ammunition (shotgun and rifle ammunition). Tin is also the most widely reported substitute to lead for lead-free pellets used in airgun and airpistols. Tin is not an EU critical raw material but like W, it is one of the four metals targeted by the EU Conflict mineral regulation. The current consumption reported in the non-critical raw material factsheet is ca. 60, 000 tons. The tonnage band reported on the ECHA website is 10,000-100,000 tons. The values from the non-critical raw material are given in Table 7. As can be seen, the EU is dependent on imports (78 %) and the end-of-life recycling rate is reported as 32 %. Substitution of all lead pellets with Tin will increase demand and like with W, increase due diligence requirements to ensure that the supply is not coming from conflict regions. Tin is also ca. 8 times more expensive than lead.[14]

Tin metal is not toxic for the environment. However, tin ions formed due to corrosion or leaching and the ions may form compounds that are toxic to the environment.

Steel: Steel shot is an alternative to lead and proposed as an alternative to projectiles in “bullet” ammunition. However currently all steel shot is imported from China meaning that EEA based manufacturers are 100 % reliant on imports. There have been supply issues in the past and EEA shotshell manufacturers face uncertainty on availability. Looking at the units given in Table 2, substitution would require the gap between 850 million units of lead shot products and 60 million units of non-lead shot to be filled (for the shot manufacturers surveyed).

Zinc: Zinc and zinc alloys are used as the projectile for a limited number centerfire bullet products. Zinc is available as a raw material.

Copper: Copper and copper alloys are used as projectiles in shot ammunition and in centerfire ammunition. Copper is available as a raw material. Note that copper from secondary sources contains Pb as an impurity (coming from recycling of brass) and the amount may be > 0.1 % (w/w). If the lead content of copper was required to be below this, copper from primary sources would need to be used. This would not be a sustainable use of primary copper.

[14] https://www.lme.com/Metals/Non-ferrous/Tin#tabIndex=0

Raw materials	Main global producers (average 2010-2014)	Main importers to the EU (average 2010-2014)	Sources of EU supply (average 2010-2014)	Import reliance rate[15]	Substitution indexes EI/SR[16]	End-of-life recycling input rate[17]
Bismuth	China (82%), Mexico (11%) Japan (7%)	China (84%)	China (84%)	100%	0.96 / 0.94	1%
Tungsten	China (84%) Russia (4%)	Russia (84%) Bolivia (5%) Vietnam (5%)	Russia (50%) Portugal (17%) Spain (15%) Austria (8%)	44%	0.94 / 0.97	42%
Tin	China (45%), Indonesia (19%), Malaysia (10%)	Indonesia 35 % Peru 24 % Malaysia 9 %	Indonesia 32 % Peru 22 % Belgium 20 % Malaysia 8 %	78 %	0.87 / 0.9	32 %

Source: compiled on the basis of the Final Report of the 'Study on the review of the list of Critical Raw Materials' 2017.

Table 7 Summary of key information from the review of the list of critical raw materials for bismuth, tungsten and tin

Q3(v) Hazard and risk of the use of alternatives, including any impacts on animal welfare;

Shotshell ammunition safety: As outlined in the wetlands restriction dossier, older shotguns may have safety issues when they are used to discharge **steel shots** as steel is harder than lead. This can be

[15] (*) The 'Import reliance rate' takes into account global supply and actual EU sourcing in the calculation of Supply Risk, and it is calculated as follows: EU net imports / (EU net imports + EU domestic production).

[16] (**) The 'Substitution index' is a measure of the difficulty in substituting the material, scored and weighted across all applications, calculated separately for both Economic Importance and Supply Risk parameters. Values are between 0 and 1, with 1 being the least substitutable.

The economic importance is corrected by the Substitution Index (SIEI) related to technical and cost performance of the substitutes for individual applications of each material. The supply risk is corrected by the Substitution Index (SISR) related to global production, criticality and co-/by-production of the substitutes for individual applications of each material.

[17] (***) The 'End-of-life recycling input rate' measures the ratio of recycling from old scrap to EU demand of a given raw material, the latter equal to primary and secondary material supply inputs to the EU.

mitigated by using modern shotguns or using bismuth or tungsten shot. More simply, owners of older shotguns that are not steel shot-proof, do not need to buy a new shotgun as they can use bismuth or tungsten shot that does not have this safety issue. It was concluded in compiled RAC-SEAC opinion[18] and later stated in the Commission draft implementing decision (Nov 2019)[19], that the use of bismuth or tungsten means that most users will not need to change their current shotgun to comply with the restriction on lead shot. The current restriction proposal would extend the ban on the use of lead shot to all activities in all terrains. This puts sports shooting in scope and hunting in non-wetland areas. This would significantly increase the number of shooters that are in the scope of the restriction. The impact would be most on sports shooters as hunters that shoot in both wetlands and non-wetlands would have considered this for their wetlands hunting. Following the logic of the COM draft implementing decision, shooters with shotguns that are not steel-shot proof can use Bi or W based shot cartridges and that there is no extra cost or safety aspect that needs to be considered. However as outlined in detail in the response to Q3 (ii) above, the use of bismuth and tungsten in ammunition is not a sustainable of these two materials that are on the 2017 list of EU critical raw materials.[5] Their supply is already critical and the EU is entirely reliant on imports for Bi and the current end-of-life recycling rate has been reported as being 1 %. The reliance on imports for tungsten is 44 % but the factsheet concludes it is an important material with no comparable alternative for uses that depend on its hardness, density, low reactivity and alloying properties. Quite simply, tungsten is too important as a raw material to be used as an alternative to lead in ammunition.

Commentato [BQ1]: Add references

Consequently the safety issue for shotgun shooting with steel shot needs to be considered given the number of users that will be in scope. New firearms will need to purchased as using Bismuth (or tungsten) shots is not a sustainable use of these two materials.

Annex III shows that of the list of certified non-lead shot that may be used in accordance with US legislation. This list is widely cited as evidence that alternatives are available. When availability and sustainability of the raw material is taken into account, solely steel and copper remain.

Also it is important to note that C.I.P. rules mean that not all shot approved in the US can be used in countries that are part of CIP. Ultra-high speed loads are not permitted under C.I.P. rules even for steel-proofed shotguns. Not all EEA countries are part of C.I.P. and some non-EEA countries are. This brings complexity to the ammunition that can be placed on the EEA market.

Forestry considerations: In addition, the potential impact on forestry needs to be considered as steel shot is the sole alternative to lead. The scope of the current proposal extends the ban on lead shot to all activities in all terrains meaning that significantly more forestry areas are now within scope. Wetland areas are generally not forested and the two countries that have already implemented bans on lead shot ammunition do not have significant forestry industry (the Netherlands and Denmark). Note that steel is more likely to penetrate young trees and the consequences will only be apparent when they are harvested up to 20 years later. When the shot has penetrated past the bark, it impacts the value of the timber as it may be discarded at the timbermill. An additional factor to consider is the potential for "sparking" when steel shot is used in non-wetland areas in terms of forest fire risks.

[18] Available on the ECHA website at https://echa.europa.eu/ro/registry-of-restriction-intentions/-/dislist/details/0b0236e180c0ac38

[19] Draft implementing decision available on the Comitology website site in dossier CMTD(2019)1325 (https://ec.europa.eu/transparency/regcomitology/index.cfm)

Ricochet risk: Lead is a soft material means that the risk from ricochet is not an issue. Projectiles made of harder materials such as steel, copper may ricochet when they hit hard surfaces. This risk will need to be factored in for each and every non-lead ammunition product in terms of its intended use. This risk would need to be taken into account in terms of the transition period for ammunition manufacturers (and firearm manufacturers) to bring on the market lead-free ammunition that does not pose a risk of injury from deflected projectiles. Shooting ranges would also need to be adapted.

Animal welfare: Current lead based ammunition have been designed and engineered for humane taking of game and vermin. Products on the market are the result of decades of optimization of ballistic performance by ammunition manufacturers in collaboration with firearm manufacturers. Non-lead ammunition can also be designed and engineered for the same purpose. This will take extensive R&D to ensure that non-lead ammunition is equally humane. As outlined in the response to Q3 (i) above, there are 100's if not 1000's of different products available. To design, engineer, test and produce non-lead alternatives will take decades. Animal welfare considerations would need to be explicitly taken into account in terms of the transition period for ammunition manufacturers (and firearm manufacturers) to bring on the market lead-free ammunition that is humane. Note that there here is no impact on animal welfare associated with sport target shooting, even if some sporting shooting range are in wetland area (depending on the definition used), due to the projectile being managed, contained, then recycled.

Environmental risks of the alternatives: Lead ammunition has been used for centuries and the behavior of the lead metal in the environment is known. Its aging and wreathing behavior in soils is known. Lead metal slowly forms compounds like oxides, hydroxides and sulfides depending on the soil chemistry and the precipitation. Lead metal and lead compounds like sulfides are poorly soluble and do not leach ions readily. This means that lead projectiles are not generally bioaccessible in soils. Other metals like Zn and Ni form compounds that are soluble and can release ions to the surface water. For materials like tungsten, very little is currently known about their environmental hazard profiles. The potential for other metals to form compounds that may leach ions to surface water needs to be considered. It would also need to be clarified if the polymers used in composite projectiles would fall under the microplastics restriction.

Q3(vi). Other potential impacts stemming from the use of alternatives, e.g., discontinuation of certain products, changes in product performance, etc.

Indoor and outdoor sports shooting: The same ammunition can be used in indoor and outdoor shooting ranges with the same firearm. The call of for evidence differentiates between indoor and outdoor shooting. If the restriction made the same differentiation a sports shooter may need two sets of firearms and ammunition for sports shooting. This cost would need to considered should the restriction differentiate between indoor and outdoor shooting. In addition, training would be challenging as the training range for the individual shooter may be indoors while the competition range may be outdoors or vice-versa. Different firearms and ammunition may need be used in training and competition.

Civilian and non-civilian supply: Ammunition manufacturers may supply for both civilian and non-civilian customers (see Table 1). As outlined in the response to Q3(ii) above, these manufacturers will have to consider the profitability of their supply to both. Continuing supply to both would mean committing to two different types of production lines with massive investment costs in terms of

equipment and new facilities. They may determine that maintaining an extensive product portfolio solely for non-civilian customers is not profitable and focus their investment on developing lead-free products for the civilian market. The size of the company, the amount of investment needed to invest in new equipment and R&D, the product portfolio and the relative contribution of civilian and non-civilian to their turnover would be key determining factors. While non-civilian uses are not within the scope of the proposed restriction, the restriction may have unforeseen consequences on its supply. This is in particular relevant for defense uses where **security of supply** considerations mean that contingency planning must be in place in the event of a sudden increase in demand (e.g. a conflict situation).

Security of supply of ammunition by the defense sector: the consequence that civilian supply lines could not be used to meet increased demand in the event of a sudden increase in demand would need to be considered (so called "surge manufacture"). Many countries in the EEA have strategic considerations in terms of the location of their suppliers and do not want to import ammunition from outside the EEA.

Previous experience in the US[20] and the UK[21] from the Iraq conflict showed that the supply was an issue due to increased demand.

The answers from the SEA-survey (see Q4) indicated that 8 companies out of the 20 supply to non-civilian (military) customers. On average, for these 8 companies, the non-civilian (military) share of turnover is 44 %. When extrapolated to the entirety of AFEMS (43), the number of companies who supply to non-civilian (military) customers is 17. According to the survey, from the different ammunition types the manufacturing of centerfire bullets is predominant in the non-civilian (military) supply.

Discontinuation of certain products: Given the number of products currently available, it is inevitable that many will be discontinued due to the significant investment costs to re-engineer a lead-free equivalent unit of ammunition. Note that each unit of ammunition has its own specifications and changing any component means re-engineering is needed. From Table 1 it can be seen that none of the responders current offer lead-free rimfire ammunition. In particular, .22 LR is not considered to have a lead free alternative. Similarly there is a lack of alternatives to centerfire ammunition that are used for high accuracy sports shooting, in particular target shooting (both rifle and pistol).

Air pellets: Pellets are used extensively in sports shooting where the accuracy and precision of the shot is dependent on the interplay between the pistol/rifle used in terms of rifling and the pellet shape, size, weight, plasticity. When used for hunting, it is used for hunting vermin. Pellets are available in different calibers each with a variety of configurations (e.g. flat-nose, round-nose, pointed, hollow-point). Each caliber may also be available in different weights. Pellets provide the highest accuracy in the rifled barrels of adult precision air rifles and air pistols. Each configuration may be available in different calibers and for each caliber in different weights.

Lead is used as the pellet material due to its combination of properties (density, plasticity, low melting temperature) meaning that it grips the rifling and deforms into the barrel dimensions and has enough weight for continued momentum. There is no other material that has the same range of properties, in

[20] https://www.rand.org/content/dam/rand/pubs/monographs/2006/RAND_MG344.pdf
[21] https://publications.parliament.uk/pa/cm199899/cmselect/cmdfence/274/27405.htm

particular plasticity and low melting temperature. Non-lead pellets are commercially available in low quantities and are generally made of tin-zinc alloys. The market share is extremely small as the ballistic performance is not sufficient for target shooting.

- Common pellet calibers: .177, .22, .25

As one of the most accurate calibers from long distances, the .177 caliber pellet is by far the most popular on the market today. As the smallest pellet of the available calibers, the .177 can be fired at the highest velocities means greater accuracy from longer distances. The .22 caliber pellet is larger in weight and size compared to .177 caliber pellets. .25 caliber is the largest of the common calibers.

The air pellet 0.17 requires extreme precision at 10 meter similarly the 0.22LR requires extreme precision at 50 meter. Every shot counts. To land a 10.9 (bullseye), the centre of the shot needs to be within a circle diameter of 0.5mm at 10m for 0.17 and within 1.6mm at 50m for 0.22. As lead is the only allowed material in the Olympic shooting events for air pistol and air rifle, competitors at local, national and international events aimed at qualifying for the Olympics will need to practice with lead pellets. The rifles and pistols used are engineered for lead pellets where the accuracy and precision of the shot is tailored to the projectile, its intended range and the spot size. There is currently no alternative to lead for pellets that gives required precision needed for target shooting. In addition, pellets can be collected and recycled in shooting ranges. As will be outlined in the next section, a derogation is requested from the proposed restriction for sports shooting.

When used for hunting, lead pellets are used for pest control. As vermin are not considered “game”, there is no risk to humans from ingesting lead fragments in game meat

Q3(vii) Are the issues in terms of shot cartridges the same as for wetlands

No. Wetlands are not forested meaning that the issues with steel shot will be different in wetlands vs. non-wetlands. Countries that have already implemented a ban on the use of lead shot do not have a significant forestry industry (Denmark and the Netherlands). As outlined above, the impact will be greater on young trees and the impact may only be apparent years later when they are mature and being processed for timber products.

Ricochet is also an issue as there are more hard surfaces in non-wetland areas. This would be in particular the case in rocky terrains.

As the risk from forest fire due to sparking of steel shot when it hits hard surfaces will be different.

Skeet and trap sports shooting will be impacted. These sports are not conducted in wetland areas. Both are Olympic sports and the ban would mean that the events could not be held in the territories of the EEA.

Q3(viii) What non-lead rifle cartridges are already used, where would substitution be problematic or costly?

Non-lead cartridges have been developed by ammunition manufacturers and the state of California maintains a list of certified non-lead ammunition for hunting in the context of the implementation of its

Assembly Bill 711. However as outlined above, the impact assessment considered that the increased costs to ammunition manufacturers would be offset by the increased demand for lead containing ammunition in sports shooting. In addition, recent initiatives by the State of California indicates that the number of hunters is decreasing.[22] While there is lead-free ammunition available, the product portfolio is limited and the production volumes are insignificant compared to lead-containing ammunition. There are also products where there may be no alternatives (specifically smallbore calibre rimfire ammunition) and many small diameter centrerfire calibers, 6 - 6,5 mm and less and all "long distance" hunting with high precision demand).

Note that many academic and literature reports conclude that as lead-free ammunition products are available, that substitution of all lead products is both economically and technically feasible.[23] These reports focus on the material of the projectile and overlook the reality that the projectile is a component of a complex engineered unit. From a hazard consideration, the projectile can be considered on its own. From ammunition perspective, it cannot be as the performance on the unit of ammunition for its intended purpose is dependent on all components. Changing any one component means that redesign and re-engineering is needed. There are 1000's of different ammunition products. Each of these products has a firearm that has been designed to discharge it. Ballistic performance comes from the interplay between the firearm and the unit of ammunition.

Table 8 below is extracted from a recent publication[24] that gives considerations on alternative projectile materials (1st three columns). It is overly simplistic as it does not consider the unit of ammunition as a whole. In particular, the claim in the column "rifle bullets or shotgun slugs", and raw "Copper, Cu" stating highly suitable either as pure or as alloy is not correct when it comes to performance and accuracy. Additional considerations on the availability of the raw material and the performance of the alternative projectile in shot and non-shot ammunition have been added (last three columns).

Metal/metal alloy	Shotgun shot	Rifle bullets or shotgun slugs	Raw material availability	Considerations for shot ammunition	Considerations for non-shot ammunition
Iron, Fe	C 99% Fe	Not suited	available	no EU production of steel shot, all shot imported from China, supply of shot not currently sufficient to replace all lead shot, ricochet risk due hardness, older shotguns are not steel-shot proof, potential for forestry damage in forested regions	risk of ricochet due to hardness, re-engineering needed every aspect from ammunition design and the firearm used

[22] https://www.sfgate.com/science/article/hunting-fishing-permit-california-fees-policy-13599231.php and https://cdfgnews.wordpress.com/2019/02/07/cdfw-magnifies-efforts-to-recruit-hunters-and-anglers/?fbclid=IwAR3BxyZOeD6vld4tlw_t8kr1beduPI68NRL30E1KH9MiDQPIO4D0-g5P8yY

[23] E.g. Thomas, V.G., Kanstrup, N. & Fox, A.D. Ambio (2019) 48: 925. https://doi.org/10.1007/s13280-018-1132-x and literature cited

[24] Thomas, V.G. Ambio (2019) 48: 1072. https://doi.org/10.1007/s13280-018-1124-x

Tungsten, W	95% W, with polymer	Any %W, when used as a densifier with other approved material	EU critical raw material, conflict mineral, alternative for other lead uses (radiation shielding, counterweight); ammunition	too important to be used as a replacement for lead in ammunition	too important to be used as a replacement for lead in ammunition
Tin, Sn	While demonstrated to be nontoxic, and unconditionally approved in Canada, the lowdensity limits use as gunshot	Not suited when used alone, but can be used in conjunction with other approved materials	Conflict mineral	density too low	Density too low, re-engineering needed every aspect from ammunition design and the firearm used
Bismuth-tin alloy, Bi-Sn	Suitable and fully approved in USA and Canada	Not suitable, due to frangibility concerns at high-velocity impacts	EU critical raw material (Bi), conflict mineral (Sn), alternative for other lead uses (radiation shielding, alloying element in brass)	supply already critical and EU 100 % reliant on imports; use in ammunition not sustainable	should not be used in ammunition
Bronze, copper-tin alloy, Cu-Sn	Suitable, especially when used in conjunction with denser tungsten	Potentially suitable, but metal hardness may be problematic	available but associated with tungsten	see comment on tungsten; see comment on lead	hardness an issue, entire unit of ammunition needs re-engineering; not just "replacing" the lead with brass; see comment on lead
Copper, Cu	Not suitable, see Fa¨th et al. (2018) for aquatic environmental concerns	Highly suitable, either as pure Cu, or as a 95% Cu—5% Zn alloy	available	as above	entire unit of ammunition needs re-engineering; not just "replacing" the lead with copper
Lead, Pb	Less than 0.1% by mass	Less than 0.1% by mass	available	lead is generally present in brass at > 0.1 % (w/w) as an alloying element to enable it to be free-machined; copper from secondary sources will contain > 0.1 % (w/w) lead meaning that copper from primary sources would need to be used	lead is generally present in brass at > 0.1 % (w/w) as an alloying element to enable it to be free-machined
Zinc, Zn	Less than 1% by mass	Allowed only as an alloying metal	available	not relevant	re-engineering needed every aspect from ammunition design and the firearm used
Nickel, Ni	Less than 1% by mass	Allowed as a bullet jacket coat	available	not relevant	re-engineering needed every aspect from ammunition design and the firearm used

Table 8 Alternatives proposed in the literature for the projectile in ammunition with additional considerations on availability of the raw material and the performance of the ammunition

Request for a derogation for sports shooting

Sports shooting is a sport that is practiced at all levels in most EEA countries. There are shooting ranges in most municipal regions and it is a sport that is inclusive and gaining in popularity. The impact assessment conducted for the California regulation on lead containing rifle ammunition for hunting (Assembly Bill 71125) stated

> "*Steady growth in the target shooting market is expected to mitigate any shifts in hunting equipment sales. Lead ammunition supplies are expected to continue to be in strong demand by target shooters*"

There are shooting events in both the winter and summer Olympics. The Olympic Program of Shooting Sport includes 15 total events of three disciplines: Rifle, Pistol and Shotgun. Olympians compete in six men events, six women events and three mixed team events.[26] The Olympic Games comprise several shotgun shooting disciplines (mens' and womens' skeet and trap, and mens' double trap) in which traditional lead gunshot is fired at moving clay targets. The disciplines and events are given in Table 9.

DISCIPLINES	MEN'S EVENTS	WOMEN'S EVENTS	MIXED TEAM EVENTS	TOTAL EVENTS
RIFLE	50m Rifle 3 Positions 10m Air Rifle	50m Rifle 3 Positions 10m Air Rifle	10m Air Rifle	5
PISTOL	25m Rapid Fire Pistol 10m Air Pistol	25m Pistol 10m Air Pistol	10m Air Pistol	5
SHOTGUN	Trap Skeet	Trap Skeet	Trap	5
TOTAL	6	6	3	15

Table 9 List of the Olympic program shooting sports at the Olympic Games

The rules on the firearms and the corresponding ammunition that can be used in these events is given in the "official statutes rules and regulations" developed by the International Sports Shooting Federation (ISSF). [27] These rules have been accepted for Tokyo Olympics in 2020. For all disciplines, lead or other soft material must be used as the projectile. For shot in skeet and trap, the rules state that "*Pellets must be made of lead, lead alloy or of any other ISSF approved material*". There is no other currently approved material. For the rifle and pistol projectiles, the rules state that the projectiles made of "lead or other (similar) soft material" are permitted.

In the winter Olympics, the biathlon is the event that combines excellence in the disciplines in cross-country and shooting. There are other international events that competitors compete in. The rules in terms of the firearm and ammunition are given in the IBU event and competition rules.[28] The biathlete carries a small-bore rifle, which must weigh at least 3.5 kg, excluding ammunition and magazines. The

[25] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB711
[26] https://www.issf-sports.org/theissf/championships/olympic_games.ashx
[27] https://www.issf-sports.org/theissf/rules/english_rulebook.ashx
[28] http://www.ffs.fr/pdf/reglements/REGBIATH/FFSreg-biat6a.pdf

rifles use .22 LR ammunition and are bolt action or “Fortner” (“straight-pull bolt”) action. The target range shooting distance is 50 m. There are five circular shooting targets to be hit in each shooting round. When shooting in the prone position, the target diameter is 45 mm; when shooting in the standing position, the target diameter is 115 mm. Manufacturers have engineered .22 LR ammunition to give the shooter the best possibly of using skill to hit the target. All projectiles in competitions are lead based as it is has the best ballistic performance. Using a different material would mean poorer ballistic performance and non-competitive shooting. Athletes would also need to learn to shoot with the new ammunition.

The implication of a ban on the use of lead containing ammunition in sports shooting would be profound. In the absence of a harmonized international approach, the ban would in effect have the following immediate consequences on international shooting competition (i.e.: Olympic shooting disciplines, world cups)

- The international target shooting events of the Olympic Games could not be held in the territories of the EEA
- No qualifying events could not be held in the territories of the EEA
- Training by EEA based Olympic athletes/competitors (international level) would need to shift to outside the territories of the EEA

A longer consequence would be the absence of new competitors from the EEA coming up through the ranks as there would no local facilities for players to start. In addition, the increased cost of non-lead ammunition (e.g. copper as a raw material is ca. 3 times more expensive than lead) will mean decreasing number of shooters.

Similarly, for the biathlon, the ban would mean

- No biathlon events (including the winter Olympics) could not be held in the territories of the EEA
- Training by EEA based athletes would need to shift outside the territories of the EEA

As for the shooting disciplines for the Summer Olympic Games, the sport would die off as no new athletes would enter as they would be no local facilities to learn or try out the sport. Economic consequences should be analyzed separately e.g. how the use of current shooting ranges would change and would the ranges stay profitable. Some estimates of the number of shooting clubs and ranges and the number of competitors are given below (not an exhaustive list)

- UK 988 clubs / 55,000 competitors (NSRA)
- Germany 14,200 clubs/ 1,35 million competitors (DSB)
- France 1619 clubs / 200,000 competitors (FTTIR)
- Norway 529 Biathlon clubs (NSA)

New rules would need to be developed for international shooting events held in the EEA. This would need to be done in agreement with sporting federations that operate globally (e.g. International Shooting Sports Federation (ISSF), International Biathlon Union (IBU), International Practical Shooting Confederation (IPSC), World Benchrest Shooting Federation (WBSF)). The timelines need to do this would need to be considered as EEA professional shooters would be at a disadvantage as there would be no international competitions in which they could compete in the EEA if there is a gap between the

restriction coming into force and new rules for competitions implemented. Note there may be also other disciplines like metallic silhouette shooting with no alternatives accepted and to be used safely.

There are no “suitable alternatives” currently available. In particular for some products, it is likely that a new caliber will be needed as no projectile material has the material properties of lead meaning that significant reengineering of the design will be needed. New calibers require new firearms and also CIP approval in countries that are bound by CIP. To develop a suitable alternative would require ammunition manufacturers, firearm manufacturers and the sporting bodies working in collaboration to agree on new performance specifications for competitive sports shooting. It is not down to the single ammunition manufacturers to develop an alternative, as there would be no demand with the current rules. They would also need to collaborate with firearm manufacturers to adapt the performance of the rifle or pistol to get the best performance with the new piece of ammunition. However, competitors will not purchase either as they would be at a competitive disadvantage. As outlined previously, countries that are part of C.I.P. would also need to follow their standards on what the ammunition that can be sold.

The following costs for manufacturers need to be considered

- Higher energy cost to make the projectiles
- Higher raw material costs
- R&D costs and the timelines needed to bring the new products on the market
- Redesign of firearms in terms of performance and safety

The areas where sports shooting is conducted are controlled access areas and in many EEA countries there are very strict measures in place to ensure that the risk to both the shooters, the general public and the environment are controlled and minimized. These include the UK (Home Office Circular 031-20016, Health & Safety at Work Act 1974, NSRA Design, Construction and Maintenance of Target Shooting Range – Code 1500010020) and Germany (e.g. Bundesministerium des Innern : Bekanntmachung der Richtlinien für die Errichtung, die Abnahme und das Betreiben von Schießständen (Schießstandrichtlinien)). The areas where lead projectiles are discharged are known, can be controlled and effective risk management measures readily put in place. Harmonizing good practices already in place for managing shooting ranges already in place in many member states is a more proportionate option to control risk.

Request for a derogation for sports shooting

A derogation from the scope of the restriction is specifically requested for ammunition used in sports shooting (shotshell, pellet and rim and centerfire ammunition) as the ban would result in the ultimate non-participation of EEA competitors in international shooting events (i.e. the Olympics and qualifying events). In contrast to the other uses of lead containing ammunition, there is no risk to man via the ingestion of game shot with lead ammunition and no risk to birds in wetlands as the shooting ranges are controlled areas (target shooting). The spent lead can also be readily collected and recycled.

It is proposed that harmonization of best practices for shooting range environmental management across the EEA to ensure that lead is recycled and run-off of leached lead ions to ground water is prevented. For example, the UK has a comprehensive set to guidelines in place for shooting range environmental permits. This would be a more proportionate risk management measure.

Q4 Information on socio-economic impacts in response to a possible restriction

Supply chain

The ammunition manufacturing industry is represented by AFEMS. In this analysis, AFEMS is considered representative for the entire ammunition manufacturing industry in the EEA. AFEMS has 74 members. 6 of those are lead producers. 43 use lead in manufacturing ammunition. The rest are distributors or dealers, shooting associations, testing and machinery companies. It is possible that not all ammunition companies belong to AFEMS but for simplicity it is assumed that figures extrapolated to cover AFEMS represents the entire industry.

The ammunition supply chain can be divided in four levels. Lead suppliers and producers are in the first level. There are 6 lead producers in AFEMS. Gun manufacturers are also included in this level because the specifications for ammunition comes from them.

Ammunition manufacturers are in the second level of the supply chain. The main categories for ammunition can be presented as gunshot (shotshell), bullet and pellet. Nevertheless, within gunshot and bullet categories there are many sub-categories. Gunshot manufacturers consist of projectile manufacturers, loaders and component manufacturers (excluding projectile). Bullet manufacturers consist of projectile manufacturers, RIMFIRE and CENTERFIRE loaders, and RIMFIRE and CENTERFIRE component manufacturers. Pellet manufacturing is a simpler process and it consist only of manufacturers. In addition, there are supporting companies e.g. for machinery, testing and OEMs. It is characteristics for the ammunition manufacturers that they perform many of these roles/activities. AFEMS has estimated that from its members:

- 21 are gunshot projectile manufacturers
- 10 are gunshot loaders
- 18 are gunshot component manufacturer (other than shot)
- 21 are Bullet projectile manufacturer
- 1 is a RIMFIRE bullet loader
- 2 are CENTERFIRE bullet loader
- 9 are RIMFIRE component (excl. projectile) manufacturer
- 13 are CENTERFIRE component (excl. projectile) manufacturer
- 6 are Pellet manufacturer
- 10 are other

Distributors and dealers are in the third level of the supply chain. There are 17 companies in AFEMS who distribute ammunition. The fourth level is consisted of consumers, namely hunters and sport shooters and associations which represent these individuals.

The analysis performed in this comment is focused on the second and third level of the supply chain. Most of AFEMS members are manufacturing and distributing ammunition.

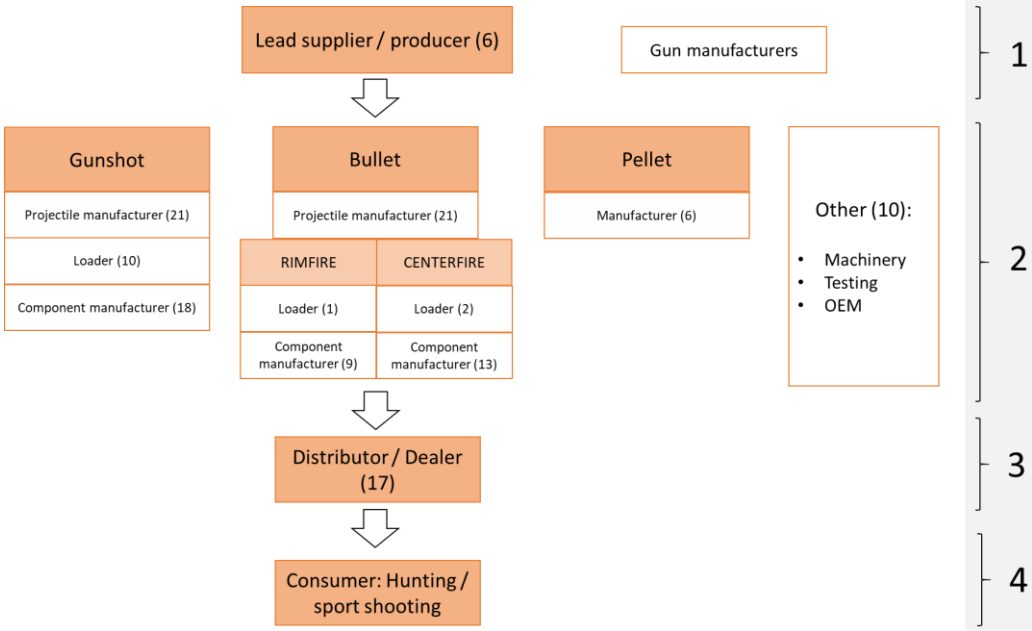


Figure 1 Supply chain

Descriptive business information of the industry

In the preparation of this comment, it was decided to survey the industry to have the most accurate data. 20 different companies from the second level of the supply chain participated in the survey. All the information presented below is based on the aggregation, calculation or extrapolation of the answers for the survey.

Survey results

Main business figures describing the entire industry by AFEMS members (20 answers)

- 20 companies answered to the questionnaire
- Total annual turnover (19 answers): 1,188 M EUR
- Average annual turnover (19 answers): 63 M EUR
- Weighted average of EEA share of turnover: 69 %
- Weighted average of turnover generated with products containing Lead: 82 %
- Expected annual growth rate: 6 %
- Total annual profit (15 answers): 71 M EUR
- Average annual profit (15 answers): 4.8 M EUR
- Weighted average of EEA share of profit: 45 %
- Weighted average of profit generated with products containing Lead: 84 %
- Total annual tonnage: 63,688 t
- Average annual tonnage: 3,352 t
- Volume development in the future

    - 53 % increase
    - 42 % stable
    - 5 % decline
- Overall number of employees: 5,746
- Average number of employees: 302
- Turnover per employee: 0.21 M EUR
- Weighted average of employees' jobs dependent on Lead: 95 %
- Average annual median salary: 36,000 €

Extrapolation to the entirety of AFEMS

The information was extrapolated to cover all AFEMS 43 lead manufacturing companies. These following are considered to be the maximum for the ammunition industry in the EEA:

- Total annual turnover: 2,689 M EUR
- Total annual turnover from the EEA: 1,846 M EUR
- Total annual turnover from products containing Lead: 2,208 M EUR
- Total annual profit: 205 M EUR
- Total annual profit from the EEA: 92 M EUR
- Total annual profit from products containing Lead: 171 M EUR
- Total annual tonnage: 137,000 t
- Overall number of employees: 12,354
- Overall number of employees' jobs dependent on Lead: 11,740
- Average annual median salary: 36,000 €

It is to be noted that some of the large companies did not provide profit information. The discrepancy between turnover and profit information is believed stemming from the missing profit information rather than small profit margin of the industry.

Share of products containing lead

In the survey share of products containing lead were asked. Please see below:

Share of products containing lead in general in your company (average)				
All products	Gunshot (or gunshot components, or gunshot ammunition loading)	Bullets rimfire (or bullets components, or bullets loading)	Bullets centerfire (or bullets components, or bullets loading)	Pellets (or pellets components)
88 %	94 %	92 %	77 %	65 %

Table 10. Share of products containing lead

For the ammunition industry share of lead in the products is very high. On average the share in all products is 88 %.

Use specific analysis

This analysis is focused on the companies that use lead in manufacturing ammunition. It is characteristic for these companies that they perform many of these activities: they produce different kind of ammunition and distribute it to the users. Some of the companies are so-called generalists who provide many kinds of ammunition. There are also companies, specialists, which are specified only to one or two uses.

To cover most of the characteristics of the manufacturing and the restriction proposal, lead uses are separated to 8 different use cases in this analysis. These uses are:

1. Lead used in producing gunshot (or gunshot components, or gunshot ammunition loading) for hunting birds and other animals (e.g. rabbits) in non-wetland areas
2. Lead used in producing gunshot (or gunshot components, or gunshot ammunition loading) for 'sports' target shooting, including training (e.g. clay pigeons)
3. Lead used in producing RIMFIRE bullets (or bullet components, bullets loading) for hunting any animal (e.g. deer)
4. Lead used in producing CENTERFIRE bullets (or bullet components, bullets loading) for hunting any animal (e.g. deer)
5. Lead used in producing RIMFIRE bullets (or bullet components, or bullet loading) for 'sports' target shooting (outdoor only)
6. Lead used in producing CENTERFIRE bullets (or bullet components, or bullet loading) for 'sports' target shooting (outdoor only)
7. Lead used in producing pellets for hunting any animal (e.g. deer)
8. Lead used in producing pellets for 'sports' target shooting (outdoor only)

Results of the survey by use cases

USE 1

- 13 companies answered
- Average share of overall production: 61 %
- Total annual turnover: 165 M EUR
- Average annual turnover: 13 M EUR
- Weighted average of EEA share of turnover: 65 %
- Total annual profit (11 answers): 11 M EUR
- Average annual profit (11 answers): 1 M EUR
- Weighted average of EEA share of profit: 66 %
- Total annual tonnage: 18,552 t
- Average annual tonnage: 1,546 t
- Employees jobs dependent on the use: 78 %

USE 2

- 13 companies answered
- Average share of overall production: 65 %
- Total annual turnover: 136 M EUR
- Average annual turnover: 10 M EUR
- Weighted average of EEA share of turnover: 78 %
- Total annual profit (11 answers): 5.7 M EUR
- Average annual profit (11 answers): 0.5 M EUR
- Weighted average of EEA share of profit: 65 %
- Total annual tonnage: 10,889 t
- Average annual tonnage: 907 t

- Employees jobs dependent on the use: 79 %

USE 3

- 2 companies answered
- Average share of overall production: 5 %
- Total annual turnover: 2.5 M EUR
- Average annual turnover: 1.25 M EUR
- Weighted average of EEA share of turnover: 77 %
- Total annual profit: No answers
- Average annual profit: No answers
- Weighted average of EEA share of profit: No answers
- Total annual tonnage: 75 t
- Average annual tonnage: 37.5 t
- Employees jobs dependent on the use: 1.5 %

USE 4

- 5 companies answered
- Average share of overall production: 33 %
- Total annual turnover: 93 M EUR
- Average annual turnover: 19 M EUR
- Weighted average of EEA share of turnover: 90 %
- Total annual profit (3 answers): 3.3 M EUR
- Average annual profit (3 answers): 1.1 M EUR
- Weighted average of EEA share of profit: 57 %
- Total annual tonnage: 651 t
- Average annual tonnage: 130 t
- Employees jobs dependent on the use: 29 %
- There is one large company which is very dependent on this use

USE 5

- 5 companies answered
- Average share of overall production: 32 %
- Total annual turnover: 47 M EUR
- Average annual turnover: 9.3 M EUR
- Weighted average of EEA share of turnover: 54 %
- Total annual profit (2 answers): 6.3 M EUR
- Average annual profit (2 answers): 3.1 M EUR
- Weighted average of EEA share of profit: 31 %
- Total annual tonnage: 1,528 t
- Average annual tonnage: 306 t
- Employees jobs dependent on the use: 43 %

USE 6

- 5 companies answered
- Average share of overall production: 45 %
- Total annual turnover: 182 M EUR
- Average annual turnover: 36 M EUR
- Weighted average of EEA share of turnover: 60 %
- Total annual profit (3 answers): 15 M EUR
- Average annual profit (3 answers): 5 M EUR
- Weighted average of EEA share of profit: 46 %
- Total annual tonnage: 4,325 t
- Average annual tonnage: 865 t
- Employees jobs dependent on the use: 42 %
- There is one large company which is very dependent on this use

USE 7

- 2 companies answered
- Average share of overall production: 40 %
- Total annual turnover: 11 M EUR
- Average annual turnover: 5.5 M EUR
- Weighted average of EEA share of turnover: 95 %
- Total annual profit (1 answer): 0.1 M EUR
- Average annual profit (1 answer): 0.1 M EUR
- Weighted average of EEA share of profit: 95 %
- Total annual tonnage: 2,055 t
- Average annual tonnage: 1,028 t
- Employees jobs dependent on the use: 51 %

USE 8

- 4 companies answered
- Average share of overall production: 25 %
- Total annual turnover: 17 M EUR
- Average annual turnover: 4.3 M EUR
- Weighted average of EEA share of turnover: 85 %
- Total annual profit (2 answers): 0.1 M EUR
- Average annual profit (2 answers): 0.05 M EUR
- Weighted average of EEA share of profit: 95 %
- Total annual tonnage: 2,522 t
- Average annual tonnage: 631 t
- Employees jobs dependent on the use: 95 %

Use specific extrapolation to the entirety of AFEMS

As mentioned, AFEMS estimates that from its members:

- 21 are gunshot projectile manufacturers

- 10 are gunshot loaders
- 18 are gunshot component manufacturer (other than shot)
- 21 are Bullet projectile manufacturer
- 9 are RIMFIRE component (excl. projectile) manufacturer
- 13 are CENTERFIRE component (excl. projectile) manufacturer
- 1 is a RIMFIRE bullet loader
- 2 are CENTERFIRE bullet loader
- 6 are Pellet manufacturer

These doesn't match directly to 43, which is the number of manufacturers, because the companies perform several activities.

The number of the companies who responded to this questionnaire is outlined next by profile:

- 4 gunshot projectile manufacturers
- 12 gunshot loaders
- 6 gunshot component manufacturers (other than shot)
- 9 Bullet projectile manufacturer
- 5 RIMFIRE component (excl. projectile) manufacturer
- 4 CENTERFIRE component (excl. projectile) manufacturer
- 5 RIMFIRE bullet loader
- 6 CENTERFIRE bullet loaders
- 3 Pellet manufacturers

Extrapolating use specific figures to cover the entire AFEMS is difficult because companies perform several uses and several roles in their activities, and the discrepancy between the number of companies for each activity estimated by AFEMS and answers provided by companies in the survey. Nevertheless, for the purpose of extrapolation it is assumed that in AFEMS, 17 companies are related to gunshot, 9 companies to rimfire, 11 companies to centerfire and 6 companies to pellets. Results of this extrapolation can be seen as maximum of the industry.

Results of the extrapolation:

USE 1

- Total annual turnover: 215 M EUR
- Total annual turnover from the EEA: 140 M EUR
- Total annual profit: 17 M EUR
- Total annual profit from the EEA: 11 M EUR
- Total annual tonnage: 24,260 t

USE 2

- Total annual turnover: 178 M EUR
- Total annual turnover from the EEA: 139 M EUR
- Total annual profit: 8.7 M EUR
- Total annual profit from the EEA: 5.7 M EUR
- Total annual tonnage: 14,240 t

USE 3

- Total annual turnover: 11.2 M EUR
- Total annual turnover from the EEA: 8.6 M EUR
- Total annual profit: No profit info
- Total annual profit from the EEA: No profit info
- Total annual tonnage: 338 t

USE 4

- Total annual turnover: 205 M EUR
- Total annual turnover from the EEA: 186 M EUR
- Total annual profit: 12 M EUR
- Total annual profit from the EEA: 6.8 M EUR
- Total annual tonnage: 2,387 t

USE 5

- Total annual turnover: 84 M EUR
- Total annual turnover from the EEA: 25 M EUR
- Total annual profit: 28 M EUR
- Total annual profit from the EEA: 8.9 M EUR
- Total annual tonnage: 6,877 t

USE 6

- Total annual turnover: 401 M EUR
- Total annual turnover from the EEA: 241 M EUR
- Total annual profit: 53 M EUR
- Total annual profit from the EEA: 25 M EUR
- Total annual tonnage: 15,858 t

USE 7

- Total annual turnover: 33 M EUR
- Total annual turnover from the EEA: 32 M EUR
- Total annual profit: 0.6 M EUR
- Total annual profit from the EEA: 0.57 M EUR
- Total annual tonnage: 6,165 t

USE 8

- Total annual turnover: 26 M EUR
- Total annual turnover from the EEA: 22 M EUR
- Total annual profit: 0.3 M EUR
- Total annual profit from the EEA: 0.3 M EUR
- Total annual tonnage: 7,566 t

Restriction scenario

In the survey, it was asked from the ammunition manufactures that what would they do if the proposed restriction would happen. In the survey, companies were able to select more than one option from the following list of possible scenarios:

- Stop producing gunshot
- Stop producing pellets
- Stop producing RIMFIRE bullets
- Stop producing CENTERFIRE bullets
- Only producing gunshot & bullets/pellets for military use
- Keep producing gunshot for export
- Keep producing pellets for export
- Keep producing RIMFIRE bullets for export
- Keep producing CENTERFIRE bullets for export
- Substitution to an alternative raw material in short term (0-3 years)
- Substitution to an alternative raw material in longer term (5-10 years)
- Something else

There were several combinations of answers, but the common analogue can be summarized as follows. Restriction on the consumers' end-use affects severely to the manufacturers' business. It affects differently for the companies which are relying on the European market than for those who sell also to the rest of the world. European ammunition industry is very dependent on the EEA market as 69 % of the AFEMS members turnover is made in the EEA market. Those manufacturers who mainly produce for the European market face the severest difficulties. They will stop producing ammunition for these 8 uses completely at the least for a moment. The duration is dependent on their ability to substitute to another raw material and end-users' willingness to substitute. Only few said they can substitute in short term (0-3 years). Majority of manufacturers outlined that they can substitute in longer term (5-10 years). Some of the companies are not able to substitute at all. Those companies who sell also to the rest of the world continue to do so and focus on export. It is clear from the survey that those companies who are not able to substitute immediately or sell to customers out of the EEA will have to stop producing these 8 uses and for the majority of those companies it means a complete shutdown of their business. As the case is also in ammunition industry the large companies might be able to focus on export and substitute in short term, but the small and medium size companies will definitely suffer from the vanishing of over 90 % of their markets.

However, in case of restriction at least the EEA shares of these 8 uses would be lost. The impacts would thus be severe in terms of lost jobs and lost turnover. The impacts are analysed in the next chapter.

To give more insights to the views of the companies, some of their responses are quoted below.

"Relocation is likely to happen because the head of our holding is not in the EEA. Research and development are necessary lasting a long time. Using alternatives is difficult because not so many possibilities are investigated up to now. For our company the restriction situation would be very problematic, because our main market is in the EEA. The high prices of our products are restricting the entrance to markets overseas. So only niche products are able to compete on other markets."

"If we have to stop the use of lead, we will see a big decrease in market consumption and there will not be an alternative in the next years."

"Surely, we will be forced to substitute the lead pellets immediately. We would need to assess the market. Assuming it stays the same size, we would need to invest in new machines for use with steel shot. The cost will be 2 million euros and the time to take delivery of new loading machines could be quite some time. If the market contracts, depending upon the market size we would reduce our work force accordingly or if not profitable simply close the business. A note to consider, steel shot is the only viable pellet material. It is currently made almost exclusively in China. I do not know about the manufacturing capacity of the steel pellets by China for the future if all of Europe must use steel shot. Also, we sell air guns, these are only accurate with lead pellet. There are millions of air guns in circulation. We may not be able to sell these guns if the market rejects the reduced accuracy of these air guns."

"*Without lead bullets and lead ammunition for civil use the fixed costs would rise so high that continuing the production will not be possible. We have to close down the factory."*

"We would need to make large investments in new machinery to produce the alternative gunshots as it is a different manufacturing process, this could take many years. There is not enough steel shot produced to sustain the current volumes of lead gunshots. There would be a huge cost difference of the alternative because it will be limited in its production and the energy costs to produce it would be far greater than lead. We would have to have a long-term investment in the manufacture of additional components that would be required to use alternative shot across the whole range of gunshots we currently use."

"In consequence of total ban of lead the company would have to seriously consider closure of all activities. There is not alternative to lead with same technical characteristics and comparable costs."

Impacts of restriction and cost-benefit analysis

If this restriction happens, in the worst case, the whole industry described at the beginning of this analysis is in danger.

For the reason of simplicity and conservativity, it is assumed that socio-economic benefits of manufacturing ammunition for those 8 uses are lost in the EEA. But it is probable that companies are not able to continue exporting so also overall values from those 8 uses are presented below. It is assumed that aggregated values from the answers for the survey are minimum impacts and the extrapolated values are maximum impacts.

The analysis is focused on turnover rather than profit because it is more transparent since some companies didn't provide profit information. However, for completeness, the profit information is also presented below. The discrepancy between turnover and profit information is believed to stem from the missing profit information rather than small profit margin of the industry.

<u>USE 1</u>

- Annual turnover losses: 165-215 M EUR
- Annual turnover losses in the EEA: 107-140 M EUR
- Annual profit losses: 11-17 M EUR
- Annual profit losses in the EEA: 7-11 M EUR

- Job losses (to/employee = 0.21) by turnover losses: 786-1,024 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 510-667 jobs
- Welfare cost from job losses: 87-113 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 56 M EUR to 73 M EUR[29]
- Total socio-economic cost (annual turnover losses and welfare cost): 252-328 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 163-213 M EUR

USE 2

- Annual turnover losses: 136-178 M EUR
- Annual turnover losses in the EEA: 106-139 M EUR
- Annual profit losses: 5.7-8.7 M EUR
- Annual profit losses in the EEA: 3.7-5.7 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 648-848 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 505-662 jobs
- Welfare cost from job losses: 71-93 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 56 M EUR to 73 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 207-271 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 162-212 M EUR

USE 3

- Annual turnover losses: 2.5-11.2 M EUR
- Annual turnover losses in the EEA: 1.9-8.6 M EUR
- Annual profit losses: No profit info
- Annual profit losses in the EEA: No profit info
- Job losses (to/employee = 0.21) by turnover losses: 12-53
- Job losses (to/employee = 0.21) by EEA turnover losses: 9-41 jobs
- Welfare cost from job losses: 1.3 M EUR to 5.8 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 1-4.5 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 4-17 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 3-13 M EUR

USE 4

- Annual turnover losses: 93-205 M EUR
- Annual turnover losses in the EEA: 84-186 M EUR
- Annual profit losses: 3.3-12 M EUR

[29] To capture all welfare cost of unemployment SEAC (https://echa.europa.eu/documents/10162/13555/seac_unemployment_evaluation_en.pdf/af3a487e-65e5-49bb-84a3-2c1bcbc35d25) and Dubourg (https://echa.europa.eu/documents/10162/13555/unemployment_report_en.pdf/e0e5b4c2-66e9-4bb8-b125-29a460720554) have proposed default values for one job lost. In EU28 the value is 2.72 times the annual pre-displacement wages of this job. In EU28 the employer tax rate is 25 % and mean duration of unemployment 1.5 years. Average median annual salary for AFEMS members is 36,000 €. The welfare cost to society equals to: (1-0.25) * 36,000 € * 1.5 * 2.72 * job losses = welfare cost. This formula is used thorough the analysis.

- Annual profit losses in the EEA: 1.9-6.8 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 443-976 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 400-886 jobs
- Welfare cost from job losses: 49-108 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 44 M EUR to 98 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 142-313 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 128-284 M EUR

USE 5

- Annual turnover losses: 47-84 M EUR
- Annual turnover losses in the EEA: 25-45 M EUR
- Annual profit losses: 6.3-28 M EUR
- Annual profit losses in the EEA: 2-8.9 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 224-400 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 119-214 jobs
- Welfare cost from job losses: 25-44 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 13 M EUR to 24 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 72-128 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 38-69 M EUR

USE 6

- Annual turnover losses: 182-401 M EUR
- Annual turnover losses in the EEA: 109-241 M EUR
- Annual profit losses: 15-53 M EUR
- Annual profit losses in the EEA: 7-25 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 867-1,910 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 519-1,148 jobs
- Welfare cost from job losses: 96-210 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 57 M EUR to 126 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 278-611 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 166-367 M EUR

USE 7

- Annual turnover losses: 11-33 M EUR
- Annual turnover losses in the EEA: 10-32 M EUR
- Annual profit losses: 0.1-0.6 M EUR
- Annual profit losses in the EEA: 0.1-0.57 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 52-157 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 48-152 jobs
- Welfare cost from job losses: 5.7 M EUR to 17.3 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 5.3 M EUR to 16.7 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 17 M EUR to 50 M EUR

- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 15-49 M EUR

USE 8

- Annual turnover losses: 17-26 M EUR
- Annual turnover losses in the EEA: 14-22 M EUR
- Annual profit losses: 0.1-0.3 M EUR
- Annual profit losses in the EEA: 0.1-0.3 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 81-124 jobs
- Job losses (to/employee = 0.21) by EEA turnover losses: 67-105 jobs
- Welfare cost from job losses: 9 M EUR to 14 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 7 M EUR to 12 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 26-40 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 21-34 M EUR

TOTAL USES 1-8

- Annual turnover losses: 654-1,153 M EUR
- Annual turnover losses in the EEA market: 457-814 M EUR
- Annual profit losses: 42-120 M EUR
- Annual profit losses in the EEA market: 22-58 M EUR
- Job losses (to/employee = 0.21) by turnover losses: 3,114-5,490 jobs
- Job losses (to/employee = 0.21) by turnover losses in the EEA market: 2,180-3,887 jobs
- Welfare cost from job losses: 343 M EUR to 605 M EUR
- Welfare cost from job losses (derived from EEA market turnover): 240 M EUR to 428 M EUR
- Total socio-economic cost (annual turnover losses and welfare cost): 997-1,758 M EUR
- Total socio-economic cost (annual turnover losses in the EEA and welfare cost): 697-1,248 M EUR

To summarise, if this restriction will be put in to force in its entirety and the companies are not able to export the products for these 8 uses, the total socio-economic cost for the first year would be between 883 and 1,556 M EUR. As the mean duration of unemployment is 1.5 years for the second year, the total cost would be between 768 and 1,355 M EUR. For the third year and annually after that until the end-user satisfactory substitution is finished for the manufacturing, the total annual cost (only turnover) would be between 654 M EUR and 1,153 M EUR.

If the companies can export with current rest of the world market share, the products for these 8 uses, the total socio-economic cost for the first year would be between 617 and 1,099 M EUR. As the mean duration of unemployment is 1.5 years for the second year the total cost would be between 537 and 957 M EUR. For the third year and annually after that until the end-user satisfactory substitution is finished for the manufacturing, the total annual cost (only turnover) would be between 457 M EUR and 814 M EUR.

However, the most probable situation is that some of the companies can export and some cannot. Thus, the most realistic impact is between these two above summarized scenarios.

From the use specific analysis can be concluded that the proposed restriction especially for procurers of gunshot (shotshells) and centerfire bullets (uses 1, 2, 4 and 6) would have a severe impact on the manufacturers and the EEA society.

Key findings from the socio-economic analysis

The key learnings from the socio-economic analysis undertaken was the large size and the complex characteristics of the industry, and that the proposed restriction would have severe negative socio-economic impacts, annual monetary losses potentially up to **1 Billion euros** and **over 5,000 jobs lost** in the EEA, on the ammunition manufacturers and the related European society.

The ammunition manufacturers are a multiform group of companies and perform several activities. Some of the companies are specialized only to one activity and some have very broad offering covering all types of ammunition. Thus, it is very difficult to classify them only to one activity category. This analysis concludes that overall there are 43 ammunition manufacturers in the EEA.

Annually the industry records a turnover of nearly 3 Billion euros and employs over 12 thousand employees. The industry is very dependent on the EEA market as the weighted average of EEA share of turnover is 69 %. The industry is similarly very dependent of lead. 82 % of turnover is generated with products containing lead. Share of lead in the products is very high. On average the share in all products is 88 %. The industry expects their business to increase with average growth rate of 6 %.

Dependent on the manufacturers ability to export and the share of the EEA market the total socio-economic cost, comprising of annual monetary losses and welfare cost, for these 8 uses would be between 697 and 1,758 M EUR. In terms of unemployment the welfare cost is between 2,180 and 5,490 lost jobs in the EEA.

Annex I Terminology used to collect information for the call for evidence

Term	*Means*
Gunshot ammunition	ammunition containing shot (the type of ammunition covered by the wetlands restriction
bullet ammunition	ammunition that is NOT gunshot and NOT pellets (ECHA call for evidence uses "bullet")
pellets	ammunition used in airguns/airpistols
RIMFIRE ammunition	non-shellshot ammunition with rimfire firing mechanism
CENTERFIRE ammunition	non-shelllshot ammunition with centerfire firing mechanism
Gunshot projectile manufacturer	you make the shot for loading into shotshell cartridges
Gunshot ammunition loader	you load the components (primer, wadding, shot to the cartridge casing) to shotshell ammunition; i.e. you prepare pieces of finished ammunition
Gunshot component manufacturer (other than shot)	you make the wadding, the casing, the primer, etc. but not the lead shot
Bullet projectile manufacturer	you make the lead or non-lead projectile for non-shotshell ammunition
RIMFIRE component (excl. projectile) manufacturer	you make any component of rimfire ammunition excluding the projectile
CENTERFIRE component (excl. projectile) manufacturer	You make any component of centerfire ammunition excluding the projectile
RIMFIRE bullet loader	You load or assemble or manufacture rimfire ammunition; i.e you prepare finished pieces of ammunition
CENTERFIRE bullet loader	You load or assemble or manufacture centerfire ammunition; i.e you prepare finished pieces of ammunition
Pellet manufacturer	You makes lead pellets for use in airguns/airpistols
Distributor / dealer	You buy ammunition for resale
Consumer (hunter / sport shooter)	You use ammunition
Profit	Net Sales - Cost of Sales = Gross profit

Annex II Non-exhaustive list of calibers by ammunition type and activity for shotshell and non-shotshell ammunition

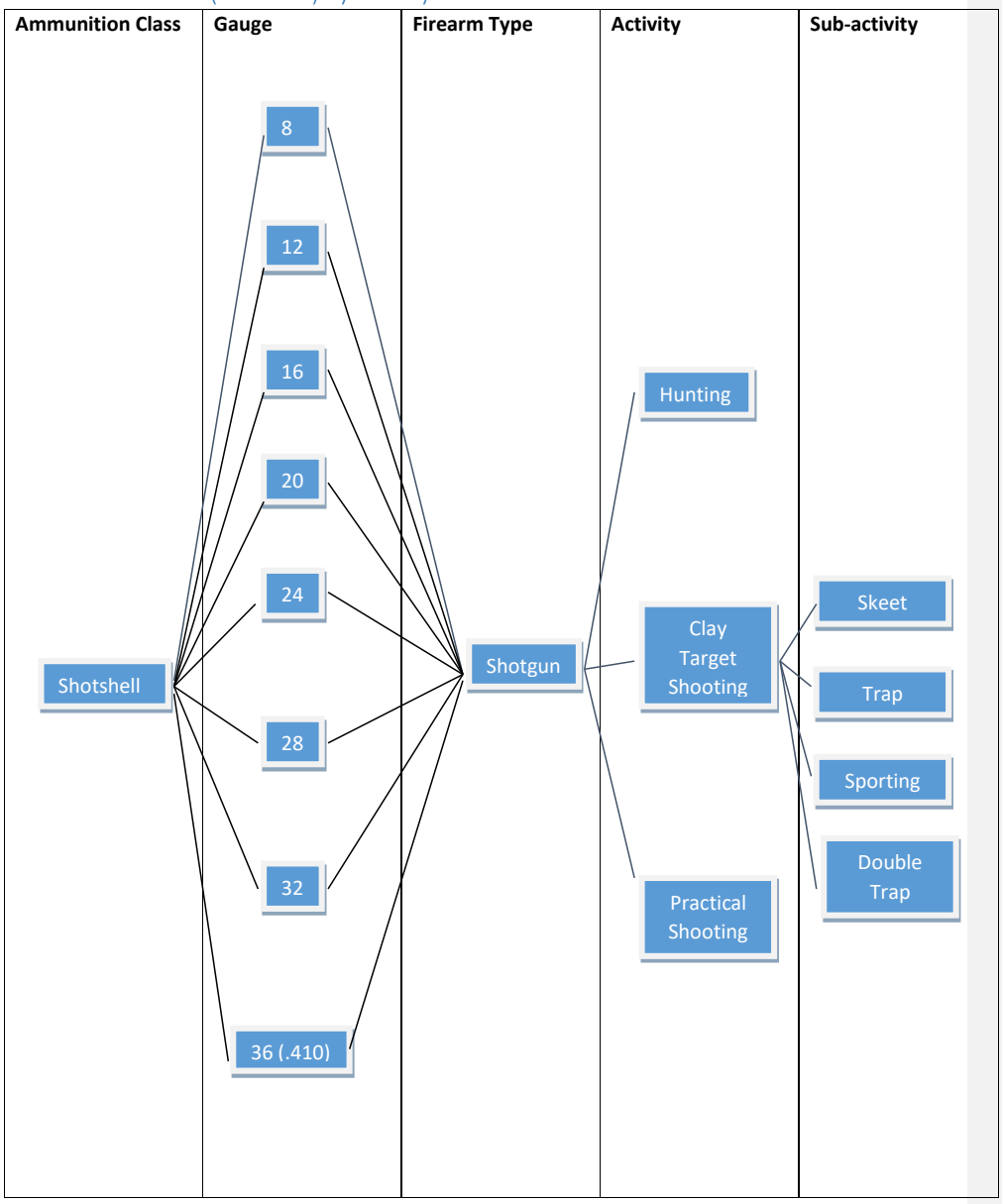
AII.i Non-exhaustive list of calibers for shotshell ammunition and by activity

Gauge
8
12
16
20
24
28
32
36 (.410)

Hunting
8
12
16
20
24
28
32
36 (.410)

Sport Shooting
12
20
28
36 (.410)

AII.ii Non-exhaustive schematic showing the combination of products possible for one ammunition class (shotshell) by activity



AII.iii Non-exhaustive list of non-shotshell ammunition calibers

Caliber
.222 Rem
.222 Rem Range
.222 Rem Mag
.223 Rem
.223 Rem Range
.22-250 Rem
.243 Win
25-06 Rem
260 Rem
260 Rem Range
6.5 Creedmoor
6.5 Creedmoor Range
7.62x53R
7.62x53R Range
30-06 Spring
30-06 Spring Wild Boar
30-06 Spring Range
300 WSM
300 Win Mag
8.2x53R
8x57 IS
8x57 IRS
.338 Win Mag
.338 Lapua Mag
9.3x53R Finnish
9.3x62
9.3x62 Range
9,3x66 Sako
9,3x66 Sako Range
9.3x74R
.375 H&H Mag
416 Rigby
450 Rigby
500 Jeffery
6,5x55SE
308Win
30-06 Sprg

Caliber
8x57 IS
9,3x62
Midas+ .22 LR
Center-X .22 LR
Polar Biathlon .22 LR
Biathlon Xtreme .22 LR
Pistol OSP .22 LR

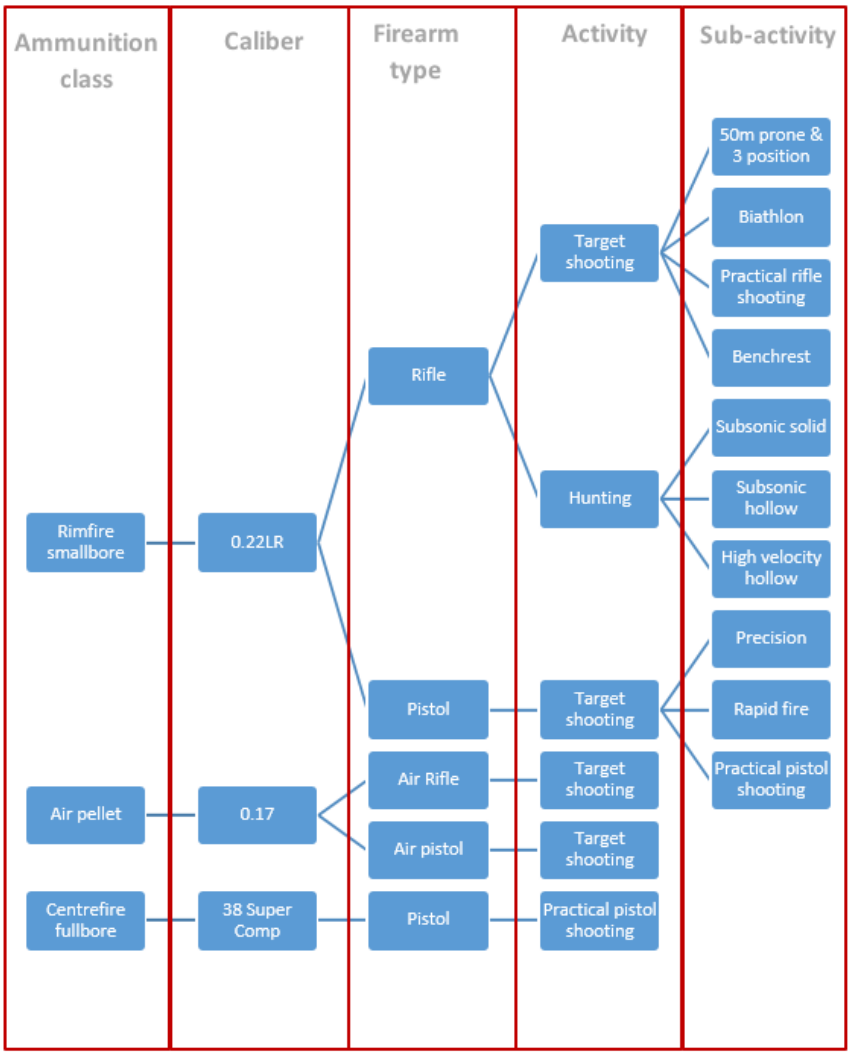
AII.iv Examples of calibers by activity (non-exhaustive)

sportshooting
.222 Remington
.223 Remington
.243 Winchester
6mm BR Norma
6.5 Creedmoor
6.5×47 Lapua
6.5×55 SE
7.62×39
.308 Winchester
.30-06 Springfield
7.62x53R
.338 Lapua Magnum
.32 S&W LWC
9 mm Luger
.22 LR
9x33 Winchester

hunting
.222 Remington
.223 Remington
.243 Winchester
6.5 Creedmoor
6.5×47 Lapua
6.5×55 SE
7×64
7x65R
7.62×39
.308 Winchester
.30-06 Springfield
7.62x53R
8×57 IRS
8×57 IS
.338 Lapua Magnum
.300 WIN MAG
.30-06
.308 WIN

non-civilian
.308 Winchester
.338 Lapua Magnum
9 × 19
9 mm NATO
5.56 mm NANO
7.62 mmx54R
7.62 x 39
.300 WIN MAG
.300 AAC BLK
6.5 Creedmoor
.223 REM

AII.iv Schematic showing an example of some combinations of products possible for one ammunition class by firearm type and activity (more are possible)



Annex III Availability of W and Bi and sustainability of their use in ammunition

Point 7 of the Commission draft implementing decision for the lead shot over wetlands restriction has the following reference to bismuth;

(7) The Agency concluded that lead-free gunshot alternatives, such as steel and bismuth gunshot, are widely available, technically feasible and have better human health and environmental hazard and risk profiles than lead gunshot. Moreover, steel gunshot, the most likely alternative to be used, is available at a comparable price to that of lead gunshot.

However, the availability of bismuth as a general replacement to lead has not been considered in the assessment done to date.

Table 11 gives the current list of approved shot material available on Webpage of the US Fish and & Wildlife Service[30] (the first two columns are from the website)**.** Most of the listed alternatives are based on **bismuth** and **tungsten** alloys. There are three entries on the list that are not based on these metals; **steel**, **copper-clad iron** and **corrosion inhibited copper**. This is relevant for the EU as Bismuth and Tungsten are on the 2017 list of critical EU raw materials.[3]

Approved shot type*	Percent Composition by Weight	EU critical raw material list[3]	Conflict mineral[13]
Bismuth-tin	97 bismuth, and 3 tin	Bismuth	tin
Iron (steel)	iron and carbon	no	no
Iron-tungsten	any proportion of tungsten, and ≥1 iron	tungsten	tungsten
Iron-tungsten-nickel	≥1 iron, any proportion of tungsten, and up to 40 nickel	tungsten	tungsten
Copper-clad iron	84 to 56.59 iron core, with copper cladding up to 44.1 of the shot mass	no	no
Corrosion-inhibited copper	≥99.9 copper with benzotriazole and thermoplastic fluorescent powder coatings	no	no
Tungsten-bronze	51.1 tungsten, 44.4 copper, 3.9 tin, and 0.6 iron, or 60 tungsten, 35.1 copper, 3.9 tin, and 1 iron	tungsten	tungsten
Tungsten-iron-copper-nickel	40–76 tungsten, 10–37 iron, 9–16 copper, and 5–7 nickel	tungsten	tungsten
Tungsten-matrix	95.9 tungsten, 4.1 polymer	tungsten	tungsten
Tungsten-polymer	95.5 tungsten, 4.5 Nylon 6 or 11	tungsten	tungsten
Tungsten-tin-iron	any proportions of tungsten and tin, and ≥1 iron	tungsten	Tungsten, tin
Tungsten-tin-bismuth	any proportions of tungsten, tin, and bismuth	tungsten, bismuth	Tungsten, tin
Tungsten-tin-iron-nickel	65 tungsten, 21.8 tin, 10.4 iron, and 2.8 nickel	tungsten	Tungsten, tin

[30] https://www.fws.gov/birds/bird-enthusiasts/hunting/nontoxic.php.

Tungsten-iron-polymer	41.5–95.2 tungsten, 1.5–52.0 iron, and 3.5–8.0 fluoropolymer	tungsten	tungsten

*Coatings of copper, nickel, tin, zinc, zinc chloride, zinc chrome, fluoropolymers, and fluorescent thermoplastic on approved nontoxic shot types also are approved.

Table 11 list of approved non-toxic projectile material in the US (federal law for waterfowl hunting and California state law for all hunting ammunition)

Below are extracts from the RAC-SEAC Opinion available on the ECHA website. The Commission draft implementing decision is based on the Opinion.

Page 53:

Replacement and re-proofing of shotguns

In order to fire steel gunshot, shotguns have to fulfil certain safety standards, which are guaranteed by proofing the gun. There are different levels of proof depending on the capability of the gun. Standard or superior/magnum-proofed shotguns can fire standard steel and other alternative gunshot cartridges. To fire high performance steel cartridges, the gun is recommended (by the CIP[29]) to be subject to the "Steel Shot" proof, which is a more rigorous test of the gun's ability to handle the pressures and shot hardness of steel/steel-like gunshot cartridges. The majority of shotguns that are currently used can be expected to be standard-proofed as this standard was already introduced in the 1970s. Hunters wanting to be sure, have the choice of re-proofing their guns. Since many Member States do not keep a register of shotguns, or do not require any registration of the number of shotguns owned, the exact number of old guns that would need to be replaced is not known.

When switching to alternatives, shooters may have to adapt somewhat to new conditions. For steel, they will have to increase shot size, or decrease gauge, because of the lower density compared to lead. Also, it is preferable to practice at a shooting range in order to obtain a feeling for how the patterning changes. According to the Dossier Submitter, this is a natural part of a hunter's annual preparation before hunting season starts. Bismuth can be used as a drop in alternative and requires no adaptations, and tungsten is considered as favourable for good ballistics and performance.

On page 58:

Gun/ammunition retailers and forestry

The Dossier Submitter expects no negative impact on gun and ammunition retailers in the EU. SEAC has no reason to assume otherwise when it comes to ammunition retailers, since it seems reasonable that a loss in sales of lead gunshot would be compensated, at least partly, by profits of lead-free alternatives. Gun retailers, on the other hand, can be expected to gain some positive revenue in the short term from the replacement of shotguns, as also stated in the Background Document. SEAC agrees that it is a likely outcome. Evidence received in the public consultation of the SEAC draft opinion indicates that overall the impact on the forestry and veneer industry is likely to be minor (#348, 366[33]). SEAC further considers that due to the focus of wetlands, where forestry is less likely to occur compared to non-wetland areas, as well as the availability of alternatives that are softer than steel shot (e.g. bismuth and tungsten), the impact on forestry and veneer industry is likely to be limited from the proposed restriction.

Annex IV basics of rimfire and centerfire “bullet” ammunition

This Annex gives basic information on “bullet” ammunition. It is taken from information sources in the public domain and is solely intended to be used in the context of this call for evidence.

The call for evidence refers to non-shell ammunition as “bullets”. As outlined in the introduction, this refers to the projectile and not the unit of ammunition. Non-shellshot ammunition covers a diversity of ammunition classes that can differ in caliber, length, weight, shaping, tip, firing, jacketing, intended firearm in all combinations.

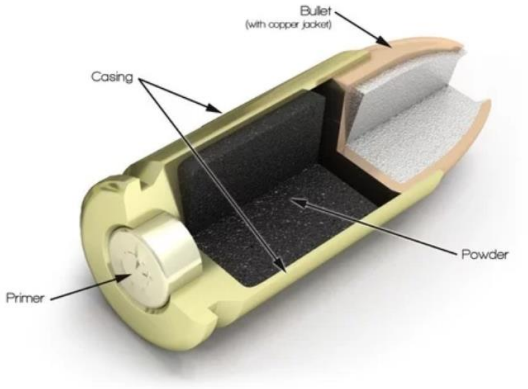


Figure 2 Schematic of a unit of ammunition or cartridge

A standard cartridge generally consists of four parts—the projectile (bullet), propellant (gunpowder), primer, and a case. A schematic of the cross-section of a cartridge is given in Figure 2. Ammunition needs primer and propellant as these work together to eject the projectile (bullet) upon firing. The primer consists of complex chemical mixtures that detonate upon firing and ignite the propellant. The propellant refers to chemical mixtures (e.g. nitrocellulose and additives) that burn and release gas creating the pressure necessary to eject the projectile. Rimfire and centerfire ammunition for rifle and small arms differ in the position of the primer at the base of the cartridge. The firing mechanism is shown schematically in Figure 3.

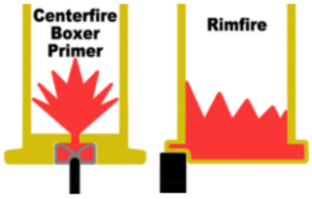


Figure 3 Schematic of rimfire and centerfire firing mechanisms

Ammunition can be grouped into two classes based on the firing mechanism. Within each class, there are different calibers, and within the calibers, different lengths, projectile weights, tips (softpoint, hollowpoint, etc.), shapes, projectile jacketing and the firearm it is designed to be used for (rifle, pistol).

Centerfire ammunition is used for rifles, shotguns, and handguns. Most centerfire ammunition is reloadable. Rimfire ammunition is limited to low-pressure loads. Rimfire cartridges are not reloadable.

The following is an overview of the ammunition for handguns taken a national handgun safety course[31] The projectile used in handgun cartridges come in various designs, sizes, and weights. The projectile usually is made of lead and may have a jacket made of copper, brass, or another metal.

- Projectiles used for hunting, law enforcement, or personal defense may have soft or hollow points designed to expand (mushroom) upon impact, Lead (.22LR) and full metal jacket too.
- Projectiles used for target shooting usually have flat orsolid points that make a clean hole in paper. Open tip type (HPBT) projectiles are also used..
- Common types of handgun projectiles are roundnose lead, full metal jacket soft point, semi-wad cutter, hollowpoint, and wad cutter.

Most handgun barrels have spiraling grooves cut or pressed into the bore. The ridges of metal between the grooves are called lands. Together, the grooves and lands are called **rifling**. When a handgun is fired, the rifling in the barrel puts a spiral spin on the projectile. This spin keeps the projectile point-first in flight, increasing accuracy and distance.

Caliber is used to describe the size of a handgun bore and the size of the cartridges designed for different bores. Caliber usually is measured as the diameter of the bore from land to opposite land and is expressed in hundredths of an inch, thousandths of an inch, or millimeters. For example, a .357-caliber handgun bore measures 357/1000ths of an inch in diameter between the lands and has a larger bore diameter than a .30-caliber handgun. However, there is no standard established for designating caliber. In some cases, the caliber is given as the diameter of the projectile, which is the distance between the grooves. Every handgun is designed for a specific cartridge. The ammunition must match the data stamp on the firearm.

Figure 4 Schematics of the bullet shapes, coatings and tips

[31] https://www.handgunsafetycourse.com/national/

Each piece of ammunition has a set of specifications that are specific for its intended use. A non-exhaustive list of commercially available ammunition by class, caliber and firearm is given in **Annex 2** to illustrate the complexity and diversity of non-shotshell ammunition.

.22 caliber long rifle rimfire ammunition: The .22 Long Rifle or simply **.22 LR** is a widely used variety of .22 caliber rimfire ammunition, and in terms of units sold, is most common ammunition in the world today. .22 LR ammunition is used in a wide range of rifles, pistols, revolvers, etc. A wide variety of .22 LR ammunition is available commercially, and the available ammunition varies widely both in price and performance. Bullet weights among commercially available ammunition range from 1.3 to 3.9 g, and velocities vary from 175 to 533 m/s. .22 LR is the least costly cartridge ammunition available. For this reason, rimfire cartridges are commonly used for target practice. The performance of a piece of ammunition depends on firearm barrel length and the type of action (i.e. the mechanism how the firearm handles the piece of ammunition) of the firearm used to discharge it.

The variety of .22 LR loads are often divided into four distinct categories, based on nominal velocity:

- Subsonic, which also includes "target" or "match" loads, at nominal speeds below 335 meters per second.
- Standard-velocity: 340–345 meters per second.
- High-velocity: 365–400 meters per second.
- Hyper-velocity, or Ultra-velocity: over 425 meters per second.

Rimfire rounds are mainly used for hunting small pests, for sports shooting and for inexpensive training. The .22 LR is the choice for several shooting events: biathlon, bullseye, plus divisions of benchrest shooting, metallic silhouette and pin shooting, and many others. It is also used in the precision Rifle and Pistol shooting events at the Olympic Games. Good quality rimfire ammunition can be quite accurate. The main advantages are low cost, low recoil, low noise and high accuracy-to-cost ratio.