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PERSPECTIVE

Hunting with lead ammunition is not sustainable: European perspectives

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Abstract Much evidence demonstrates the adverse effects of lead ammunition on wildlife, their habitats and human health, and confirms that the use of such ammunition has no place within sustainable hunting. We identify the provisions that define sustainable hunting according to European law and international treaties, together with their guidance documents. We accept the substantial evidence for lead's actual and potential effects on wildlife, habitats and health as persuasive and assess how these effects relate to stated provisions for sustainability and hunting. We evaluate how continued use of lead ammunition negatively affects international efforts to halt loss of biodiversity, sustain wildlife populations and conserve their habitats. We highlight the indiscriminate and avoidable health and welfare impacts for large numbers of exposed wild animals as ethically unsustainable. In societal terms, continued use of lead ammunition undermines public perceptions of hunting. Given the existence of acceptable, non-toxic alternatives for lead ammunition, we conclude that hunting with lead ammunition cannot be justified under established principles of public/international policy and is not sustainable. Changing from lead ammunition to non-toxic alternatives will bring significant nature conservation and human health gains, and from the hunter's perspective will enhance societal acceptance of hunting. Change will create opportunities for improved constructive dialogue between hunting stakeholders and others engaged with enhancing biodiversity and nature conservation objectives.

Keywords Animal welfare · European Union · Human health · Lead ammunition · Poisoning · Sustainable hunting

INTRODUCTION

International environmental law has traditionally provided for hunting as a wise use of wildlife resources so long as it does not jeopardise the conservation status of hunted or other species and does not result in deterioration of habitats where hunting occurs. These fundamentals for sustainable and acceptable hunting assume it is conducted strictly within international and national laws, according to standards of best practice, in turn shaped by dialogue with other stakeholders, and is beneficial to society in terms of economy and conservation.

Acceptance of hunting as a legitimate sustainable use of wildlife resources has been an important facet of many international environmental instruments during the past half century. Hunting has promoted good practice in many fields, not least for management of harvestable species, controlling pests where needed, and for conservation of habitats and wider landscapes.

Waterbirds ingest shot along with grit and food. Ingested shot is often retained in the gizzard along with grit, and is rapidly mechanically eroded and dissolved by the stomach acids. The toxic salts formed are absorbed into the blood and cause poisoning. For this reason, lead gunshot[1] has been subject to legislative and other forms of regulation in 30-35 countries around the world over the last 50 years,

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[1] The term 'gunshot' refers to small pellets used in shotguns and excludes rifle bullets. The term ammunition includes both gunshot and rifle ammunition (bullets).

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especially for the protection of waterbirds and their wetland habitats (Pain 1992; Mateo 2009; Stroud 2015).

More recent research, however, reveals a wider perspective of the problem, including that waterbirds are now known to be poisoned from lead ammunition when feeding outside wetlands. Non-wetland species living in dryland habitats also ingest gunshot. There is also a growing body of strong evidence showing that lead gunshot has wider consequences than formerly appreciated for multiple bird species (as reviewed by Watson et al. 2009; Delahay and Spray 2015). For instance, food chain linkage has been found in North America between the earthworm-eating North American Woodcock *Scolopax minor* and lead gunshot, and it is possible that Woodcock *S. rusticolor* in Europe are similarly exposed to lead in their diet (Scheuhammer et al. 1998, 2003; Hiller and Barclay 2011; Lead Ammunition Group 2015). Avian scavengers, notably eagles, buzzards, kites and vultures are poisoned having consumed meat from animals with elevated tissue lead levels, or containing either lead gunshot or fragments of lead rifle bullets (Scheuhammer and Norris 1995; Pain et al. 1997; Krone et al. 2009; Gangoso et al. 2009; Hunt 2012; Berny et al. 2015; Ecke et al. 2017; Gil-Sánchez et al. 2017).

Recent studies have shown that human consumption of shot game meat is an additional dietary lead exposure and concomitant health risk, especially for children, pregnant women, foetuses and those who eat such meat regularly (EFSA 2010; Mateo et al. 2014; Green and Pain 2015; Knutsen et al. 2015).

As an environmental problem however, eliminating poisoning from lead ammunition is not an inherently complex issue. Lead toxicity has been recognised for thousands of years (Stroud 2015), and there is a large body of scientific literature on ammunition lead's impacts on wildlife as well as on human health (Arnemo et al. 2016). Non-toxic alternatives to lead exist for most hunting applications, and regulatory options through legislation are straightforward (Thomas et al. 2015; Kanstrup et al. 2016). Indeed, some countries with strong hunting traditions, e.g. Denmark, have already phased out lead shot completely, and effectively managed the problem through legislation (Kanstrup 2015). Yet in other countries, resistance remains obdurate, either at government level and/or within hunting communities, suggesting that the issues are social and/or political rather than technical (Cromie et al. 2015).

There is general consensus, reflected in statutes, treaties and guidance documents, that hunting must be sustainable in ecological, economic and social terms. As background for this analysis, we describe principles for acceptance of sustainable hunting in environmental and wildlife conservation policy, and how regional and international law, and associated guidance for its interpretation and implementation, define it. From this platform, we assess whether the growing evidence for lead ammunition toxicity clashes with the principles so established, and thus whether continued use of lead ammunition, in any context, can be regarded as sustainable.

PROVISIONS FOR SUSTAINABLE HUNTING

For the purposes of this assessment, "hunting" encompasses any lawful pursuit and killing of animals with shotguns or rifles firing either leaded or lead-free[2] ammunition.

The definition and practical implementation of hunting "sustainability" have evolved in recent decades as this issue has been painstakingly addressed in global, European and national contexts. It began in Europe with discussions and spirit of international dialogue and cooperation for conservation that prevailed after the Second World War. This was founded on recognition of the importance of pursuing research-driven conservation for wild species for their existence value as well as for the benefit of humankind. Many of those involved in drafting the text of the 1971 Ramsar Convention on Wetlands of International Importance and ensuing multilateral environmental agreements (MEAs) came from a generation of hunter-naturalists. They ensured that principled hunting as a wise use was based on the concept of hunters taking a sustainable harvest of a shared natural resource and as such, this concept was firmly embedded within these treaties.

The Ramsar Convention includes no direct reference to lead poisoning of waterbirds. However, its broadly phrased provision regarding the conservation and wise use of wetlands (Article 3) commits Parties to addressing threats to wetland ecological character, including those resulting from wetland species' harvest and release of toxic substances (Resolution VII.19; Recommendation 6.14). Multiple other legally binding international instruments contain provisions which identify principles for sustainable hunting and, either explicitly or by implication, require States to address threats posed by lead ammunition. These are briefly outlined below (see further Table S1), and are revisited in the article's subsequent discussion as relevant. Appropriate non-binding instruments and initiatives are also considered. The topic was previously addressed by Thomas and Guitart (2005), and comparison reveals a steady increase in the number of international policy instruments that promote the transition to lead-free ammunition since then.

[2] According to a general consensus but not necessarily legal applicable in all countries, 'lead-free' means that shot or bullets contain less than 1% lead by weight.

Key provisions and guidance documents

The Bern Convention and the European Union's Nature Directives

After the adoption of Ramsar, further principles for sustainable hunting were included in the Council of Europe's 1979 Convention on the Conservation of European Wildlife and Natural Habitats[3] ("the Bern Convention"), and the two primary nature conservation instruments of the European Community that implemented the Convention within European legal frameworks, the 1979 Birds Directive (79/409/EEC and 2009/147/EC) and the 1992 Habitats Directive (92/43/EEC). Each of these three instruments identifies a standard at which wildlife populations must be maintained or to which they must be adjusted (Article 2).

The Bern Convention prescribes varying levels of protection for species listed in its Appendices (Articles 5–7), and places particular emphasis upon measures to conserve habitats of Appendix II and (insofar as migratory species are concerned) III species (Article 4). Between them, the Appendices cover all bird species, with the exception of 11 abundant species regarded in many Contracting Parties as potential pests requiring control. The Birds Directive goes further by requiring a general system of protection in respect of "*all species of naturally occurring birds in the wild state*" in the EU (Article 1). The Directive requires "special conservation measures" for the habitats of Annex I and migratory species (in particular, the classification and prevention of the deterioration of Special Protection Areas—SPAs). To the extent that it permits hunting, the Directive requires that this practice does not jeopardise conservation efforts in the distribution areas of huntable species, and complies with wise use principles (Articles 4 & 7).

Twenty-two species of European waterbird have been recorded to ingest spent lead shot: eight being listed in the Birds Directive's Annex I (Mateo 2009; UNEP 2014; Pain et al. 2015). Annex I also lists a number of raptor and vulture species known to suffer from lead ammunition ingestion (see also Table S2). It follows that if lead shot is deposited in SPAs designated for these species or negatively impacts conservation efforts elsewhere, there is a clear issue for hunting to address. Indeed, the European Commission has recognised that pollution from lead ammunition "*needs to be considered in the context of wise use*" and that "*any use of it in Special Protection Areas that leads to the deterioration of habitats or significant disturbance to birds is incompatible with the protection requirements of these sites*" (*Guide to Sustainable Hunting under the Birds Directive*, see below).

The Bern Convention's Standing Committee has recommended that Parties take steps to phase out use of lead shot in wetlands or waterbird hunting and promote a general shift to use of alternatives (Recommendation No. 28[4]).

The Birds Directive requires EU Member States to "*prohibit the use of all means, arrangements or methods used for the large-scale or non-selective capture or killing of birds or capable of causing the local disappearance of a species*" (Article 8). This provision implements a similarly worded requirement of the Bern Convention (which additionally identifies poison as such a means in the non-exhaustive list provided in Appendix IV), as does Article 15 of the Habitats Directive. The precise import of the wording regarding selectivity in the two Directives and the Convention may be debated: whether in each respect it is the indiscriminate intentional method, or the effect of taking, that is material. Taken in the round however, and with emphasis on preventing deterioration of important habitats for potentially vulnerable species, as well as unintended harmful consequences for non-target species, the grain of public policy is clear: hunting sustainability depends on avoidance of methods with indiscriminate (i.e. non-selective) effects.

Notably, both Directives and the Convention identify various justifications for derogating from the prohibition on non-selective methods of killing. However, such derogations cannot be relied upon if another satisfactory solution exists. In the case of lead ammunition, non-toxic and effective alternatives are widely available, and hence derogations cannot be justified.

Finally, several international Species Action Plans developed with support of the European Commission and/or endorsed by the Bern Convention call for specific action on lead shot (Table S2).

AEWA and other instruments in the CMS family

By the time of the adoption of the African-Eurasian Migratory Waterbird Agreement (AEWA)[5] in 1995, awareness of the dangers of lead gunshot was well appreciated in Europe, although such dangers were long understood in North America (Bellrose 1964; Sanderson and Bellrose 1986; Morehouse 1992). As a result, the AEWA Action Plan contained a firm obligation for Parties to endeavour to phase out lead shot for hunting in wetlands before 2000. This has been subject to amendment and at present is formulated: "*Parties shall endeavour to phase out the use of lead shot for hunting in wetlands as soon as possible in accordance with self-imposed and published timetables"* (Action Plan 4.1.4), and with an agreed target

[3] http://www.coe.int/en/web/bern-convention.

[4] https://rm.coe.int/1680746b41.

[5] http://www.unep-aewa.org.

for this phase out to occur by 2017 (AEWA Strategic Plan 2009–2017[6]). This has since been extended until the seventh AEWA Meeting of the Parties (MOP) in December 2018 (Resolution 6.14[7]). Several Parties have entered reservations in respect of this provision. However, Parties' commitments to maintain or restore the favourable conservation status of migratory waterbirds (Article II) and ensure sustainable use (Article III) arguably require that even those states with reservations restrict the use of lead shot if such use is having a significant impact on waterbird populations (Lewis 2016). Several of the Agreement's other provisions are relevant to lead ammunition, including those concerning prohibiting indiscriminate means of taking, and developing and implementing International Single Species Action Plans (Tables S1 and S2).

Certain provisions of, and guidance developed under the 1979 Convention on Migratory Species of Wild Animals (CMS) hold wider relevance for the lead shot issue. Insofar as the use of lead ammunition degrades the habitat or impedes migration of, and/or is a factor endangering, Appendix I species, the Convention would appear to require that Parties endeavour to address this issue (Article III). Guidance adopted by the CMS Conference of the Parties (COP) explicitly encourages phase out of lead ammunition across all habitats (Resolution 11.15;[8] *Guidelines to Prevent the Risk of Poisoning to Migratory Birds*).

Exhortations concerning lead are also found in the non-binding African-Eurasian Migratory Landbirds Action Plan,[9] the Central Asian Flyway (CAF) Action Plan for the Conservation of Migratory Waterbirds and their Habitats,[10] and the Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia ("Raptors MoU"[11]).

The EU Sustainable Hunting Initiative

In 2001, the European Commission recognised the risks to practical conservation of counterproductive disagreement on a limited number of issues between some hunters and some conservationists. In order to find solutions and encourage meeting of minds, the Commission launched the Sustainable Hunting Initiative.[12] The Initiative's objective was "*to achieve and enhance sustainable hunting under the Birds and Habitats Directives*". It was envisaged as a 'win–win' for biodiversity conservation and responsible hunting, achieved "*by dialogue and cooperation between environmental and hunting organisations, and awareness-raising aimed at grassroots hunters*".

In 2004, the Sustainable Hunting Initiative was clarified by the European Commission in their *Guide to Sustainable Hunting under the Birds Directive.*[13] This was supported in October 2004 with key delivery objectives agreed[14] between BirdLife International and the Federation of Associations for Hunting and Conservation of the EU (FACE) who agreed to "*phase out lead shot for hunting in wetlands throughout the EU as soon as possible, and in any case by 2009 at the latest*". This objective mirrored the action agreed between the Commission and Member States in the 25th anniversary Birds Directive Action Plan (2004): "*Action 5–8. Aim to phase out the use of lead shot in wetlands as soon as possible and ultimately by 2009 (*[Action:] *Member States, European Commission)*".[15] It reflected AEWA commitments and exhortations from the Bern Convention's Standing Committee.

The CBD Addis Ababa Principles and Guidelines and Aichi Targets

In parallel with these developments, the 2004 COP of the 1992 Convention on Biological Diversity (CBD) adopted the Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity,[16] which provided a framework to ensure that "*no use of the components of biodiversity will lead to the decline of biodiversity*". Principle 5 specifies in particular that "*sustainable use management goals and practices should avoid or minimise adverse impacts on ecosystem services, structure and functions as well as other components of ecosystems*". Principle 11 specifies the need to minimise adverse environmental impact, including through promotion of more efficient, ethical and humane use of components of biodiversity and reduction of collateral damage to biodiversity.

CBD thus has linked sustainability of hunting to all other uses of biodiversity under a common conceptual framework. Complementary to these Principles, CBD's

[6] http://www.unep-aewa.org/sites/default/files/basic_page_documents/strategic_plan_2009-2017_1.pdf.

[7] http://www.unep-aewa.org/sites/default/files/document/aewa_mop6_res14_ext_rev_sp_poaa_en_0.pdf.

[8] http://www.cms.int/en/document/guidelines-prevent-risk-poisoning-migratory-birds-unepcmscop11doc2312annex2.

[9] http://www.cms.int/en/document/african-eurasian-migratory-landbirds-action-plan-aemlap-2.

[10] http://www.cms.int/en/document/central-asian-flyway-action-plan-conservation-migratory-waterbirds-and-their-habitats.

[11] http://www.cms.int/sites/default/files/basic_page_documents/raptors-mou_without-annexes_e.pdf.

[12] http://ec.europa.eu/environment/nature/conservation/wildbirds/hunting/index_en.htm.

[13] http://ec.europa.eu/environment/nature/conservation/wildbirds/hunting/docs/hunting_guide_en.pdf.

[14] http://ec.europa.eu/environment/nature/conservation/wildbirds/hunting/docs/agreement_en.pdf.

[15] http://edepot.wur.nl/118449.

[16] https://www.cbd.int/sustainable/addis.shtml.

Aichi Biodiversity Targets (2010) and the United Nations General Assembly's Sustainable Development Goals (2015) were developed. Notably, AEWA's MOP has formally recognised that efforts to phase out lead shot contribute to achieving several of the targets identified in these documents (Resolution 6.15).

The Council of Europe's Charter for Hunting

The Council of Europe's European Charter for Hunting (2007)[17] expanded the European Commission's Sustainable Hunting Initiative's commitment outside the EU and specified that "*sustainable hunting is the use of wild game species and their habitats in a way and at a rate that does not lead to long term decline of biodiversity or hinder its restoration*". The benefits of such a definition were seen as "*the maintenance of hunting as an accepted social, economic and cultural activity*", and that hunting "*when conducted sustainably can positively contribute to the conservation of wild populations and their habitats and also benefit society*".

Further, the Charter developed Addis Ababa Principle 11 (above) and established guidelines to regulators and managers to "*(a) Adopt rules, regulations and incentives that promote methods and equipment that minimise avoidable suffering for animals; (b) Communicate to hunters the need to treat game animals with respect; (c) Recognise and promote best practices.*" (Guideline 3.10.2.1).

LEAD AMMUNITION AND SUSTAINABILITY OF HUNTING

A fundamental principle for sustainable hunting arising from the legal instruments and supporting non-binding guidelines, agreements, and principles outlined above is recognition by all those involved that hunting is acceptable provided: that it does not jeopardise the conservation of biodiversity; is selective as to species that may be taken; and does not inflict avoidable suffering.

The provisions described above focus primarily on the threat to biological sustainability. In reality, sustainability depends on more than preventing lead ammunition's damaging impacts on populations and habitat quality. Lead ammunition raises questions about ethics and humanity (the welfare of individual animals). The indiscriminate nature of lead ammunition poisoning raises questions about collateral damage.

Sustainability depends on hunting being conducted according to law and best practice, and with continuing dialogue with other stakeholders. Hunting's sustainability is enhanced if judged to be a net economic contributor.

Below, we explore what continued use of toxic lead ammunition may mean for judgments about hunting sustainability under these biological as well as societal themes.

Lead effects on populations and biodiversity

Numbers and trends of waterbird populations at different scales are known to be strongly associated with their ingestion of lead shot (Anderson et al. 2000; Samuel and Bowers 2000; Stevenson et al. 2005; Mateo et al. 2014; Pain et al. 2015; Meyer et al. 2016; Green and Pain 2016). The widespread and cumulative deposition of lead shot in soils and wetlands has long been recognised as environmentally damaging (e.g. Bellrose 1964; Pain 1992; Green 2013; Harradine and Leake 2013; Pain and Green 2014). Such cumulative deposition diminishes habitat capacity to support quarry and non-quarry populations alike and is antagonistic to both the provision of hunting, and to the conservation of species and their habitats.

The lethal and sub-lethal consequences of ingesting lead ammunition pellets or bullet fragments are inherently non-selective. This contravenes the requirements that sustainable hunting necessarily needs to be selective. Even though direct harvest of populations may be subject to selective measures, the indiscriminately poisonous effects of lead ammunition dispersed whilst taking such harvest are clearly non-selective. Furthermore, the use of lead shot can be regarded as a "means", "arrangement" or "method" capable of causing habitat degradation and/or local disappearance of a species, including those listed in the Birds Directive's Annex I. Therefore, allowing hunting with lead shot runs counter to Birds Directive requirements. Provisions of various other international instruments concerning species and habitat conservation are also arguably breached by States' failures to endeavour to phase out lead shot.

The neurotoxic and other physiological effects of very low levels of lead on human health are well known (e.g. Needleman et al. 1979, 2002). Hunt (2012) concluded: *"There are good reasons to expect that sublethal lead is harmful [to wildlife], especially in view of the considerable body of human health literature providing evidence of multiple adverse effects associated with very small amounts of lead, together with the implication that lead physiology is broadly similar among vertebrates."* Whilst research focus on wildlife lead impacts has mainly been on acute poisoning leading to death, chronic low-level exposure to lead may be at least as significant demographically. Although much less is known about sub-lethal impacts on

[17] http://www2.nina.no/lcie_new/pdf/634991504714143702_Hunting_Charter[1].pdf.

wildlife (compared to humans), recent studies indicate a range of potentially significant effects, including, *inter alia*, sperm motility; immune responses; reduced egg production, hatching rates and duckling survival rates; power-line collision rates; bone mineralization; and movement behaviour (Edens and Garlich 1983; Kelly and Kelly 2005; Gangoso et al. 2009; Hunt 2012; Vallverdú-Coll et al. 2015, 2016; Newth et al. 2016; Ecke et al. 2017). Such adverse physiological outcomes for individuals have potential to negatively affect populations through demographic impacts on productivity and survival, and thus conflict with the Addis Ababa Principle of avoiding or minimising adverse impacts on ecosystem services, structure and functions as well as other components of ecosystems. Furthermore, to the extent that sub-lethal impacts of lead poisoning hinder maintenance or restoration of species' favourable conservation status, such impacts could have implications in terms of Article 2 of the Birds Directive, Habitats Directive, Bern Convention, and AEWA respectively. The CMS COP has additionally expressed concern regarding both lethal and sub-lethal effects of lead (Resolution 10.26).

Lead and animal welfare

It is a widespread principle, and in some countries a legal requirement, that hunting practices avoid unnecessary animal suffering. As well as being highlighted by Addis Ababa Principle 11, the Council of Europe's Hunting Charter (2007)[18] addresses animal welfare explicitly with wording applying not only to hunting per se but also *methods and equipment* used. The extent of sub-lethal effects and suffering of lead poisoned and dying animals have been little researched. There is, however, considerable expert specialist knowledge of the care that must be taken to avoid poisoning animals being kept for example in collections for public display, captivity for breeding and experimental purposes, or hawks and falcons kept for falconry.

Poisoning will arise where animals can ingest lead shot from contaminated soil or if lead ammunition-contaminated meat or carrion is fed to captive carnivores. Behaviour and symptoms of such accidentally poisoned animals is entirely consistent with extended suffering. In the wild, debilitated or dying individuals are, however, seldom observed because lead poisoned individuals will, if they can, hide themselves away when behavioural impairment reaches a certain point (Pain 1991). Up to then, birds with elevated blood and tissue lead levels derived from ammunition are known to be disproportionately vulnerable to behavioural changes that render them susceptible to being shot, predated or suffering accidents such as collision with overhead power lines (Kelly and Kelly 2005; Berny et al. 2015; Ecke et al. 2017).

The animal welfare consequences of lead ammunition use have been widely ignored because they are a difficult and emotive topic, but the UK's Lead Ammunition Group, which had the benefit of specialist veterinary expertise in the animal welfare sector, was tasked by its commissioning environment ministry, Defra, to address them. The Group concluded (Lead Ammunition Group 2015) that "*Regardless of lead's population effects, there is no doubt that, depending on the dose, lead poisoning can seriously affect health and welfare (the pathology and clinical signs being consistent with causing severe and prolonged discomfort, distress and pain) and that it can and does kill large numbers of birds. The number of birds suffering welfare problems because of ammunition-derived lead is at least as large as the number killed by lead poisoning annually*". The Group's 2015 report provided an estimation of numbers of UK animals that might be exposed to welfare effects, and concluded that non-trivial numbers are involved in the order of millions of animals. Hence, allowing large-scale dispersal of lead ammunition conflicts with well-established policy principles of avoiding unnecessary suffering.

The welfare issue should not therefore be ignored in compliance contexts given not only legal provisions to avoid unnecessary suffering where such provisions exist, wider non-binding commitments, but also ultimately in terms of public perception and social acceptability of hunting. From an animal welfare perspective, hunting that causes avoidable widespread suffering by environmental dispersal of lead is unsustainable.

Lead in relation to national laws

A primary requirement for hunting sustainability is that it should be conducted in compliance with relevant laws and regulations. Enforcement of appropriate national legislation is an essential feature of states' compliance with their international nature conservation commitments. For example, AEWA explicitly requires Parties to "*develop and implement measures to reduce, and as far as possible eliminate, illegal taking*" (Action Plan 4.1.6). In the context of lead ammunition specifically, the Agreement's MOP has urged Parties to "*establish enforcement procedures to assure national compliance with an introduced ban and to establish monitoring procedures to assess its effectiveness*"[19] (Resolution 4.1).

[18] http://www2.nina.no/lcie_new/pdf/634991504714143702_Hunting_Charter[1].pdf.

[19] http://www.unep-aewa.org/sites/default/files/document/res4_1_phasing_out_lead_shot_final_0.pdf.

In this context, compliance monitoring procedures are notably lacking or feeble, the exception being England, where post-mortems of randomly collected shot duck conducted a decade after the introduction of legislation showed that 70% had been illegally shot with lead (Cromie et al. 2010), a rate which increased to 77–82% after 15 years (Cromie et al. 2015). A questionnaire survey of English hunters showed widespread awareness of the illegality of such use of lead, with justifications for its use including denial of the problem, dislike of alternative ammunition types, and unlikelihood of prosecution (Cromie et al. 2010). Clearly such instances where hunting is being conducted illegally to a substantial extent cannot be regarded as sustainable.

Levels of compliance in other countries where regulations have been enacted have not been monitored or investigated systematically, and remain subject of speculation. Proportions of waterbirds shown by x-radiography to be carrying lead shot in their tissues picked up on their migrations have shown no signs of declining (Newth et al. 2012, 2016).

Lead in the context of community economics

Continued use of lead shot for hunting is likely to increase financial burdens on society due to, *inter alia*, continued and irreversible contamination of natural habitats. In the EU, this type of potential environmental damage is addressed by *Directive 2004/35/*[20] *(April 2004) on environmental liability with regard to the prevention and remedying of environmental damage*, which is based on the "polluter-pays principle" (Article 1). If hunters and their communities cannot be specifically identified as "polluters", restoration costs of mitigation efforts and actions to treat pollution falls on society.

The public reputation of hunting is significantly strengthened by the good reputation of game and venison as healthy low-cost sources of meat. In some European communities, notably in Scandinavia, game meat is a major component of total meat consumption. Swedish authorities, for example, have undertaken research and risk reduction through ammunition regulations, guidance to hunters and advice to consumers (Svenska Jägareförbundet 2017). Norwegian efforts to avoid lead in venison for consumption by discarding meat close to wound channels causes the discard of 200 tonnes of contaminated meat annually,[21] representing an economic loss equivalent to 3 million Euros (Arnemo, pers. comm.). UK's Forest Enterprise requires that all carcasses from deer culled for commercial woodland management is killed with non-lead ammunition. Increased precaution regarding lead content in game meat may result in shot animals not being available for sale on public markets or otherwise distributed. Under such circumstance negative economic consequences may result with implications for the financial viability of game control operations that depend on derived profits.

Much game meat contains lead levels that would be legally unacceptable in farmed meat and poultry on health grounds, rendering it unfit for sale and consumption. EFSA (2010) found that lead content in 14.1% of 754 samples of food groups exceeded 10 mg/kg, with a maximum of 867 mg/kg in muscle of Wild Boar *(Sus scrofa)*. Game meat and offal dominated. The Swedish Food Authorities found, in 2014, that one-third of minced Elk *(Alces alces)* meat samples were above the legal limit (0.1 mg/kg) for beef, pork and poultry, while more than 40% of cuts from Roe Deer (*Capreolus capreolus)*, Fallow Deer (*Dama dama)* and Wild Boar contained levels above the same threshold.[22] If identical standards (thresholds) for lead contamination in animal food products were applied to game meat, then public health controls would result in game meat originating from hunting with lead ammunition having to be discarded. This would not only undermine the wise use principle but lead to large unquantified costs. It is often suggested by hunters that use of non-lead ammunition causes extra costs. However, the costs of ammunition, no matter what type, are small relative to a hunter's total expenditure, and a much greater and long-term economic benefit accrues to estates and land owners who benefit from selling lead-free game to the public (Thomas 2015).

In summary, continued use of lead shot and other lead ammunition may mean the disposal of much shot game for human consumption is no longer possible, and an important economic and ethical underpinning of game management is lost.

Lead and hunters' reputation

Sustainability is an established and well-formulated precondition to maintenance of hunting as an accepted social, economic and cultural aspect of public policy (e.g. as embodied in the European Charter for Hunting). Sustainable use is central to the role and functioning of FACE as a representative body for European hunting. In September 2017 EU Environment Commissioner, Karmenu Vella, is reported as stating, "*Sustainable hunting is a positive force*

[20] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:143:0056:0075:en:PDF.

[21] http://www.hegnar.no/Nyheter/Naeringsliv/2016/09/Maa-kaste-200-tonn-viltkjoett.

[22] https://www.livsmedelsverket.se/globalassets/rapporter/2014/bly-i-viltkott-del-2—halter-i-bly-hos-jagarfamiljer.pdf.

for conservation".[23] Societal acceptance of hunting is less formulated and, while flowing from the principles of sustainability, is dependent on uncertain and potentially changeable public opinion. If sustainability is called into question due to continued lead ammunition use, the hunters' reputation is undermined.

Society is, for very good public policy reasons (e.g. EFSA 2010; World Health Organisation 2010; UNEP 2017), progressively phasing-out exposure to lead from multiple contexts, including in petrol, water, paints, and other products following international health consensus (Markowitz and Rosner 2003; Stroud 2015). Lead will continue to have important and indispensable commercial uses but where alternatives do not yet exist, in every instance, such continued use is very strictly regulated to protect industrial workers and the environment through rigorous recovery and recycling. In this respect, lead ammunition stands out as the striking exception.

Future generations are likely to regard the widespread discharge of lead into the environment with a similarity to past widespread use of DDT and other very harmful substances used commonly just a few decades ago but today prohibited. Continued lead ammunition use is an additional and unnecessary dietary source of lead exposure for all human consumers of food products derived from lead-shot game, as there is no safe lower limit of exposure to lead (EFSA 2010; World Health Organisation 2015). If hunting maintains a dependency on lead it will be associated by wider society as directly connected with the environmental dispersal of a toxic heavy metal pollutant with clear consequences for human health.

Continuing to resist change will damage the reputation of hunting, threaten its legitimacy, and provide argumentation for those who would wish it to cease. If such antipathy takes root, there is risk of significant loss of recreational value for millions of European citizens and of the positive role that wise and sustainable hunting can provide for rural economies, management and conservation (Laws 1997; FACE 2004).

Lead and meaningful dialogue

The European Commission's Sustainable Hunting Initiative and *Guide to Sustainable Hunting under the Birds Directive* explicitly seek to encourage meaningful dialogue as a requirement of sustainability. AEWA and the Bern Convention also contain provisions for general awareness raising. The governing bodies of both treaties have issued explicit calls for awareness and educational programmes regarding lead shot (e.g. Bern Convention Recommendation No. 28[24]). The responsiveness of Member State/Contracting Parties' statutory bodies, and of hunting authorities, to the need for dialogue, awareness and educational programmes also shapes perceptions of sustainability.

The problems arising from lead shot have been a topic of regular dialogue between stakeholders at international level since the early 1990s (Pain 1992). Hunting and environmental organisations both recognised the need to be led by the evidence to develop alternatives that would be non-toxic to wildlife as well as effective, safe, available and affordable for hunting. Nonetheless, evidence of wider problems than are accepted to occur in wetlands, and that are well documented and agreed by many wildlife and public health authorities (Health Risks from Lead-Based Ammunition in the Environment 2013; Group of Scientists 2014), are vigorously contested in non-peer-reviewed reports and magazine articles by hunting and ammunition trade lobbyists who cite authorities of their own (Countryside Alliance 2013; Holmgren 2014; Batley et al. 2016). There is a blatant disregard of studies (e.g. Anderson et al. 2000; Stevenson et al. 2005) that show the large savings of wildlife which accompany non-toxic gunshot use.

Reluctance to act on lead reduction by the European Parliament and EU Member States reflects current vested interests of sporting communities (Thomas and Guitart 2010). Questions about efficacy of lead alternatives (Thomas et al. 2015) have been allowed to take root within hunting communities with little sign of effort by responsible hunting bodies to engage in sustained dialogue, correct misunderstandings, raise awareness, or deliver conservation outcomes. Such inclination to defend an indefensible status quo has echoes of similar behaviour by the paint industry to defend toxic leaded paints, and gasoline and car industries who sought to retain leaded fuels—as documented in detail by Markowitz and Rosner (2003), Michaels (2008), Needleman and Gee (2013).

There is little evidence that governments, hunters' communities and other stakeholders have made any significant or sustained investment in delivering promised measures to upgrade relevant communications, awareness raising, and pro-active promotion of best practice concerning this issue. Unfortunately, some attitudes in the hunting community have become entrenched, with the issue seen in antagonistic and competitive terms. Such attitudes make behavioural change difficult, as explored by Cromie et al. (2015).

Though many national hunters' organisations and their international associates positively support needs to phase out lead shot—at least for hunting in wetlands—lack of

[23] http://mailchi.mp/face/face-press-release-problematic-proposal-restricting-the-importation-of-hunting-trophies-into-the-eu-raises-deep-concerns-1050125?e=cc43aa01d2.

[24] https://rm.coe.int/1680746b41.

proactive campaigning to this end, including lack of actions to improve legislative enforcement, reveals shortcomings in dialogue, and to that extent compromises hunting sustainability.

Lead and European conservation efforts

The EU is a key player in international efforts to halt loss of biodiversity and sustain wildlife populations and habitats through its legislation, policies and planning, e.g. through the Birds and Habitats Directives and the creation of the Natura 2000 protected area network (Romão et al. 2013). Furthermore, the Union is a Contracting Party to many multilateral environmental agreements. In this role the EU can establish and support (e.g. through its LIFE funding programmes) nature conservation programmes. In this context, the use of lead hunting ammunition is a key issue.

The lead shot issue is becoming increasingly a touchstone for the international wildlife management community. As early as the mid-1990s, AEWA required that Parties endeavour to completely phase-out the use of lead shot for hunting in wetlands by 2000, and this issue has subsequently attracted considerable attention from subsequent AEWA MOPs. Since the coming into force of AEWA, many Parties have taken steps to regulate lead shot in wetlands (Stroud 2015), though actual enforcement and compliance with regulations is poor or unknown in those few countries where this has been actually assessed (above; Cromie et al. 2002, 2010). The fact that the international nature conservation community has not made clear progress on this rather simple environmental policy issue calls into question the ability of this community to handle other, and some even more serious and complex, environmental challenges. So, the lead issue can be seen as a 'Litmus Test' on the basic ability of international conservation bodies to deliver actual results in a time when these are more needed than ever.

ALTERNATIVES

The evidence that lead ammunition is a source of poisoning for wildlife, pollution of ecosystems and additional dietary health hazard for regular human consumers of game is substantial. Though this, per se, questions the sustainability of continued use of such ammunition for hunting, authority and hunter hesitation to take responsive action might be explained by falsely stated lack of alternative ammunition. However, it is a matter of practical reality that effective non-lead and non-toxic alternatives are widely available at market prices comparable with lead ammunition (Thomas 2013; Thomas et al. 2015). Companies in eight European countries already produce non-toxic materials for hunting and shooting, and are not the limiting factor in this issue (Thomas and Guitart 2010). Examples from countries that have already phased out lead ammunition types through regulation show that such initiatives do not negatively affect hunting, whether in terms of participation or harvest levels, or indeed of unretrieved losses. The Danish example of a total ban on lead shot for hunting has demonstrated that this can be achieved without jeopardising hunters' interests or weakening the hunting community. On the contrary, it is believed, though never scientifically investigated, that the public image value of hunting not being connected to a pollutant such as lead is of importance for the perception and long-term political sustainability of hunting (Kanstrup 2015). This further accentuates the conclusion that future hunting strategies, if based on lead ammunition, cannot be considered as sustainable.

CONCLUSION

The continued use of lead ammunition is incompatible with European states' commitments under several international instruments and conflicts with established principles for sustainable hunting. Impacts on wildlife population processes and potential for reduction of population numbers of some hunted and non-hunted wildlife, including rare and threatened species, mean that hunting with lead ammunition is not sustainable in either ecological or wildlife conservation terms. The collateral toxic effects of lead ammunition, avoidable health and welfare impacts for large numbers of exposed wild animals are ethically unsustainable and reinforce this conclusion. In societal terms, continued use of lead ammunition undermines a broadly ambivalent public perception of responsible hunting. Continued use of lead ammunition is an additional and avoidable dietary lead exposure for human consumers of food products made from lead-shot game. This additional exposure not only conflicts with public policy goals of removing all avoidable exposures to lead, but also creates objective and significant population-scale health risks for regular consumers, especially children and pregnant women.

The history of the movements to reduce and eliminate other polluting exposures to lead, including from work places and industrial processes, paints, water supply systems and fuel, records such changes to have been slow, costly and divisive—but ultimately successful. In moving forward from use of toxic lead ammunition to non-toxic alternatives, it would be wise to heed warnings from the past as described in European Environment Agency (2013).

Changing[25] from toxic lead ammunition and encouraging use and further development of existing well-functioning non-lead ammunition types will improve recognition of hunting as a widely accepted, sustainable and wise practice in the 21st century. Doing so will, moreover, benefit conservation efforts; revitalise international strategies for nature conservation; bring significant conservation gains; and open doors to constructive dialogue and beneficial cooperation.

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