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PERSPECTIVE

Considering the switch: Challenges of transitioning to non-lead hunting ammunition

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ABSTRACT

In this issue of *The Condor: Ornithological Applications*, Haig et al. (2014) summarize negative impacts of lead ammunition and fishing tackle on birds and discuss strategies for mitigating risks to wildlife and human health. Their Review raises an important set of questions for hunters, wildlife managers, and conservation scientists. Effective mitigation will require careful understanding of technical, economic, and social dimensions of the problem. Here, I focus on challenges specific to adopting non-lead ammunition for hunting, particularly for large game animals. I discuss limitations of using the ban on lead ammunition for waterfowl hunting as an analog for reducing lead use for other types of hunting, explain important technical considerations in design and use of non-lead ammunition, and point out areas where effective non-lead alternatives are still lacking. I suggest that currently available economic analyses of the cost of non-lead alternatives are inadequate and do not recognize wide variation in hunter behavior. These considerations have strong implications for designing effective outreach and predicting responses of hunters asked to consider non-lead alternatives. Enforcing outright bans on using lead ammunition for all types of hunting, as recently enacted in California, may prove even more challenging than similar restrictions for waterfowl hunting. Despite this, I propose that major reductions in exposure of wildlife and people to lead bullet fragments are achievable, particularly through outreach and incentive programs that focus on the most commonly used types of firearms for big game hunting—high velocity modern rifles. Bullets from these widely used rifles typically produce the most lead fragments and have the best selection of effective non-lead options available at this time. Efforts to change hunter behavior must recognize the true costs and challenges of changing to non-lead ammunition. Likewise, hunters should recognize and accept their important role in wildlife conservation and work to embrace effective alternatives to lead as they become available.

Keywords: ammunition, bullets, hunting, lead, hunter outreach

Considerando el cambio: Los retos de la transición a municiones de cacería libres de plomo

RESUMEN

En esta edición de *The Condor: Ornithological Applications*, Haig et al. (2014) resumen los impactos negativos sobre aves de las municiones de cacería y aparejos de pesca de plomo, y discuten estrategias para mitigar riesgos a la fauna silvestre y la salud humana. Su análisis plantea varias preguntas importantes para cazadores, directores de manejo de fauna, y científicos de la conservación. Mitigación efectiva requerirá un conocimiento cuidadoso de las dimensiones técnicas, económicas, y sociales del problema. Aquí, me concentro en los retos específicos asociados con la adopción de municiones de caza libres de plomo, en particular las que se utilizan para animales de caza mayor. Discuto las limitaciones de usar la prohibición del uso de municiones de plomo para la caza de aves acuáticas como un análogo para la reducción del uso de plomo para otros tipos de cacería, explicando los factores técnicos importantes en el diseño y uso de municiones libres de plomo, señalando áreas donde aún hacen falta alternativas libres de plomo que sean efectivas. Sugiero que los análisis económicos disponibles del costo de alternativas libres de plomo son insuficientes y no reconocen la amplia variación en el comportamiento de cazadores. Estos factores tienen fuertes implicaciones sobre el diseño efectivo de programas de divulgación y la predicción de las reacciones de cazadores a los cuales se les pide considerar alternativas libres de plomo. La ejecución de prohibiciones completas del uso de municiones de plomo para todo tipo de caza, como se promulgó recientemente en California, podría resultar ser más difícil que restricciones similares sobre la caza de aves acuáticas. Sin embargo, sugiero que reducciones importantes en la exposición de fauna silvestre y humanos a fragmentos de balas de plomo son alcanzables, especialmente a través de programas de divulgación e incentivos que se concentran en los tipos de arma utilizados con mayor frecuencia para la caza de animales de caza mayor, rifles de alta velocidad modernos. Las balas de estos rifles muy utilizados típicamente producen el mayor número de fragmentos de plomo, y tienen la mejor selección de alternativas libres de plomo hoy disponibles. Intentos de cambiar el comportamiento de cazadores deben reconocer los verdaderos costos y retos de hacer la transición a municiones libres de plomo. De igual forma, los cazadores deben reconocer y aceptar su importante papel en la conservación de la fauna silvestre y trabajar para aceptar alternativas efectivas al plomo a medida que estén disponibles.

Palabras claves: municiones, balas, cacería, plomo, programas de divulgación a cazadores

In this issue of *The Condor: Ornithological Applications*, Haig et al. (2014) review the extensive evidence for negative effects of lead ammunition and fishing tackle on birds. Lead bullet fragments in viscera removed by hunters from game animals and in animals shot but not recovered have posed a major problem for conservation of the California Condor (*Gymnogyps californianus*) (Walters et al. 2010). Lead from bullet fragments, shot, and fishing tackle has caused mortality or debility for affected individuals of many other species (Haig et al. 2014). Concerns about effects of ingested lead ammunition on waterfowl were brought to the forefront more than 20 years ago, and resulted in a gradual ban of lead pellets in shotgun ammunition used for waterfowl hunting in the United States and later in Canada. The subsequent decline in lead-poisoned waterfowl (Anderson et al. 2000) is a striking conservation success story, but the prohibition of lead shot for waterfowl hunting was contentious, slow, and difficult (Friend et al. 2009). Moreover, as I explain below, that transition is not necessarily an appropriate analog for the shift from lead to less toxic (hereafter, non-lead) materials for bullets used for hunting with rifles and handguns.

Banning lead ammunition in waterfowl hunting was in large part enabled by authority provided to the US Fish and Wildlife Service by federal regulations such as the Migratory Bird Treaty Act and the Endangered Species Act (Friend et al. 2009). As Haig et al. (2014) describe, regulations on use of lead ammunition in other hunting and shooting contexts and lead fishing tackle are a complicated patchwork of state, local, and even landowner-specific regulations. Outside of waterfowl hunting, most attempts to reduce use of lead ammunition for other types of hunting have occurred so recently that data on the effectiveness of different approaches are largely lacking. One strategy is to ban use of all lead ammunition in hunting. A complete ban was implemented in 2008 in California Condor habitat in California, and is now required to be phased in statewide by 2019. A second strategy is to develop programs to encourage hunters to switch voluntarily to non-lead ammunition, in particular for hunting big game species such as deer, elk, or bear (e.g., Arizona; Haig et al. 2014). Attempts to reduce the use of lead ammunition in hunting or lead tackle in fishing must, however, be informed by a clear understanding of the cost, performance, availability, and suitability of non-lead alternatives across the extremely varied situations in which these items are used. Haig et al. (2014) point out that there are many sources of mortality for wild birds in North America, including predation by domestic cats (Loss et al. 2013), window strikes (Loss et al. 2014), and vehicle strikes. Haig et al. (2014) argue that mortality from lead ammunition and fishing tackle is a tractable problem that could be addressed to the benefit of birds. While many aspects of the problem may be tractable, others are less so. Effecting a change in human behavior, whether by mandatory or voluntary approaches, requires "buy in" by the people affected by the change. Thus, the key question is: Will hunters and fishers buy in?

Here, I explore why some hunters may strongly resist switching to non-lead ammunition, identify instances where lead reduction efforts may be most effective, and discuss some of the technical, economic, and social aspects of the problem. I focus on rifle and handgun ammunition rather than fishing tackle. Ballistics (i.e. performance of ammunition) is a complex field largely beyond academic research available to conservation scientists, and many aspects of hunter and shooter behavior relevant to this issue have not been quantified through appropriate surveys. Therefore, in discussing some of the complexities that hunters and shooters must confront when asked to change to a very different type of ammunition, I am forced to rely on personal expertise to a larger degree than is typical, drawing on 30 years of experience with hunting, competitive shooting, making ammunition, and recently seeking and testing effective alternatives to lead ammunition. As Haig et al. (2014) point out, research on the technical, economic, and social sides of this issue is badly needed to inform possible policy decisions.

Technical Considerations—Why Finding Effective Alternatives Can Be Challenging

First, it is important to consider fundamental functional differences between shotguns and rifles and pistols. Shotguns are the only legal type of firearm for hunting waterfowl in the United States. Shotguns used for that purpose propel several hundred small pellets simultaneously out of a smooth-sided gun barrel, which works well when trying to hit fast-moving objects at relatively close ranges (<50 m). In the United States, supplying and regulating distribution of shotgun ammunition (shells) with non-lead shot is simplified because only six gauges (barrel diameters) are available (10, 12, 16, 20, 28, and .410), and two gauges (12 and 20) comprise the vast majority of use by hunters. In contrast, there are dozens of non-interchangeable types of rifle and handgun cartridges that are commonly used for hunting, and dozens, if not hundreds, that are used less commonly. For example, the 2008 edition of the Barnes reloading manual (Barnes Bullets 2008) lists 83 different rifle cartridges, and many more are omitted. Rifle and pistol bullets are fired singly, spun by spiraling grooves (rifling) in the gun barrel that stabilize the bullet in flight for long-range accuracy. Bullets need to be as accurate as possible so that hunters avoid wounding and not recovering animals and can maximize the range at which game can be taken. Accuracy is highly affected by factors idiosyncratic to particular combinations of individual firearms and types of bullets. Waterfowl hunters often fire hundreds of shells per season, whereas a hunter pursuing some types of big game may have waited years to draw a tag resulting in a single opportunity for a shot. Thus, the performance of even a single bullet may have huge significance to a big game hunter, resulting in reluctance to change to a new bullet design.

In order to kill game animals quickly and humanely, a modern (post circa 1900) bullet is designed to expand to create a larger wound channel. This result is usually achieved by wrapping a soft lead core in copper alloy and leaving lead exposed at the bullet's nose. Expansion must be reliable across a wide range of distances (e.g, 10–400 m), over which velocity changes dramatically as the bullet loses speed due to air resistance. Less toxic materials for bullet construction, such as copper and copper alloys, are usually much less dense than lead; they are also less malleable. Therefore, to design a bullet with 1) mass similar to the lead-based bullet it is intended to replace and 2) reliable expansion across a wide range of impact velocities requires significant changes in bullet design, such as increased length. Each change in bullet design causes a cascade of problems that must be solved. For example, how can we fit a longer bullet into a cartridge case that is already mostly filled with powder, without changing the overall length of the cartridge such that it would no longer fit in the firearm? How can bullets be changed without raising pressures inside the firearm to unsafe levels? How can we ensure that the new bullet will still be properly stabilized by the rifling in the barrel, and that it expands reliably when it strikes an animal? The transition to non-lead ammunition for waterfowl hunting also incurred redesigns in ammunition, and caused changes in firearm design. Older shotguns with softer steel barrels could not safely be used with steel shot, so some hunters were forced to buy new shotguns, and there were many concerns raised about safety, cost, and poor effectiveness of early non-lead alternatives (Lombardi 1989, Friend et al. 2009). Using non-lead ammunition for all other hunting applications will result in an even wider array of challenges given the extensive array of cartridges and projectiles that must be adapted.

Despite these complexities, bullet designers and ammunition manufacturers have developed effective non-lead options for many types of firearms, particularly for some of the most common firearms and ammunition types used for big game hunting. Many hunters report equivalent or better performance of non-lead bullets in those applications (e.g., Trinogga et al. 2013). However, it is important to recognize that equally effective non-lead options do *not* yet exist for all types of firearms used in hunting, including one of the most common cartridges used in the United States: the rimfire .22, used for small game hunting. While non-lead .22 ammunition using bullets made of tin is available, many shooters report that it does not function well (or at all) in some common types of .22 firearms, especially semi-automatic firearms that require pressure from heavier bullets to self-load. Other firearms for which non-lead options are very limited or unavailable include: 1) traditional muzzleloading firearms (designs dating to before circa 1865, loaded with loose black powder and a separate bullet rather than a self-contained cartridge), 2) firearms from the black powder cartridge era (designed before circa 1900) which are widely used in the highly popular "Cowboy Action" shooting competitions and by many hunters, especially in states where use is permitted in primitive weapons deer seasons, and 3) some modern hunting rifles chambered for less common cartridges. A survey in the late 1990s estimated that 30% of hunters nationwide used muzzleloaders at least occasionally (Duda et al. 1998); in a 1999 South Dakota study, the majority of people hunting with muzzleloaders used traditional-style versions (Boulanger et al. 2006). When non-lead options for those older styles of firearms do exist, in my experience switching between non-lead bullets for hunting and the much cheaper lead bullets for practice can be impractical: where the bullet strikes at typical shooting distances can change so radically that it may be difficult or impossible to adjust the sights to accommodate different points of aim.

Better Assessment Is Needed of the Economic Costs

The economic burden for individual hunters switching to non-lead ammunition has also been inadequately described. Thomas (2013) surveyed costs of different ammunition types sold by a major online and mail-order retailer and, based on the average cost across lead and non-lead types, concluded that there was no significant economic impact to switching to non-lead ammunition. That conclusion is only correct for a particular class of hunters: Those who shoot ammunition assembled with premium quality lead-core bullets such as the Nosler Partition will see little price difference when switching to non-lead options, barring the initial cost of testing different brands or developing different loads to find one that performs well in a particular firearm. However, based on my anecdotal observations of what ammunition is actually sold in popular retail outlets and used in the field, I conclude that many or even most hunters use cheaper brands of lead-based ammunition (e.g., Remington Core-Lokt) that are 1/2 to 2/3 the cost of non-lead options (note costs reported in table 2 of Thomas 2013). Thus, any forecast of economic impact must include a survey of what types of ammunition hunters actually use rather than basing conclusions on the average cost of what is available for purchase online.

Moreover, forecasts of economic costs based on average hunter behavior do not capture the impact to some individuals; patterns of ammunition use vary widely among users. Some hunters fire their rifle only once or twice a season to check their sights or when actually shooting at game, and thus will incur little additional cost even if using ammunition that costs 2–3 times more. Others fire hundreds or thousands of rounds a year in order to develop and test accurate loads, enhance their shooting skills, or participate in shooting competitions using the same firearms with which they hunt. Many hunters and shooters purchase loaded ("factory") ammunition, but a large number of hunters and shooters prefer to reload ammunition, assembling their own customized cartridges from a wide selection of components. Users of traditional muzzleloaders, pre-1900 cartridge firearms, and some types of handguns may even cast their own lead bullets, resulting in extremely low costs per bullet and great flexibility in developing loads optimized for a particular firearm. Many hunters have learned to reload copper or copper alloy bullets in place of lead core bullets, and recipes and components for such loads are increasingly available, such as the hundreds of non-lead loads presented in the 2008 Barnes reloading manual (Barnes Bullets 2008). Even with published recipes, however, loads must be developed for each individual rifle to find the safest and best-performing combination, which can be a time-consuming and expensive process involving many experiments. Thus, economic analyses of the average impact of switching to a different type of ammunition may be totally inadequate at describing the burden of increased costs on some individual shooters. Does this mean that such hunters cannot switch to non-lead options? No—but the response of such individuals in considering that switch will likely differ from hunters who rarely practice and use only factory-loaded ammunition. Informed surveys of hunter behavior would shed light on these questions and should be a research priority.

Would Outright Bans Be Enforceable and Effective?

Another important question to consider is whether mandatory bans on lead ammunition for hunting, such as that in California, will be effective and enforceable. Many rifles and handguns are used for purposes other than hunting, particularly recreational and target shooting, meaning that lead ammunition will continue to be in high demand and probably widely available even if banned for hunting. Furthermore, many hunters possess enough of their favored type of ammunition or reloading components to last for many years. Waterfowl hunting in many regions is often aggregated, with hunters concentrated on public waterways and wildlife refuges that are managed for hunting, where game wardens can predictably find and check large numbers of hunters for compliance. The distribution of hunters pursuing other types of game is more diffuse. Although enforcement of big game regulations can be accomplished efficiently in some locations, large and small game are hunted across the United States on private lands or remote public lands where enforcement attempts may be almost entirely absent unless a violation is reported by a member of the community. Additionally, not all types of non-lead bullets or ammunition are readily distinguishable from lead-core versions, leading to the potential that hunters may be required to surrender ammunition for testing. Given the prevalence of poaching and other illegal behavior in hunting (Musgrave et al. 1993), it is unclear whether a ban on all lead ammunition would affect behavior of enough people engaged in hunting or shooting of animals to have the intended consequences. Indeed, Finkelstein et al. (2012) reported that the 2008 ban of lead ammunition within California Condor range in California has not yet reduced blood lead levels for that species, perhaps because of lack of compliance. Hunting laws perceived as unfair or as threats to Second Amendment rights may even provoke defiant behavior (Filteau 2012), underscoring the need for buy-in by the hunting community.

Reduction of Lead Is Possible through Informed Outreach

Despite the issues that I raise here, I believe that major reductions in lead exposure for wildlife resulting from lead ammunition are achievable. In addition to the conservation implications of using lead ammunition, concerns about the effects of lead ammunition on human health (Hunt et al. 2009, Knott et al. 2010), particularly in young children who frequently consume game meat, may motivate some hunters to abandon lead ammunition. By focusing outreach and incentives on modern centerfire rifles, which are the most common types of firearms used for the vast majority of big game hunting, it may be possible to greatly reduce exposure of scavengers, other wildlife, and human consumers to lead fragments. Moreover, this approach would not disenfranchise hunters who use firearms such as muzzleloaders and black powder cartridge rifles for which practical and affordable non-lead bullets are not yet available. High-velocity lead-core ammunition used on big game fragments to a much greater degree upon impact than ammunition fired from muzzleloaders or black powder cartridge rifles (D. Sanchez, C. Epps, D. Taylor, personal communication), or other low-velocity firearms such as handguns, and thus likely poses the greatest risk to wildlife and human consumers of game meat (Hunt et al. 2006, Hunt et al. 2009). Fortunately, such modern high-velocity hunting rifles have the greatest variety of non-lead alternative bullets available, and many of those bullets appear to be highly effective for common hunting applications (Knott et al. 2010, Trinogga et al. 2013). High velocity modern rifles have been the primary focus of ammunition trade-in programs such as the "Hunters as Stewards" program developed by the Yurok tribe of northern California (C. West, personal communication). In my discussions with hunters and shooters, and in the survey of the Arizona lead reduction program reported by Sieg et al. (2009), hunter satisfaction with non-lead bullets for these most common hunting rifles appears to be very high, although not uniformly positive. Sieg et al. (2009) also report more than 80% compliance by hunters in the voluntary area. In many cases, hunters may just need to be exposed to the new ammunition in a way that reduces initial cost and overcomes limited availability of non-lead options. Hunters also need to be educated about other considerations, such as the potential for smaller exit wounds due to reduced fragmentation, greater penetration (which can be both positive and negative), and reloading techniques specific to non-lead bullets. Not all problems have been adequately solved, particularly developing an effective non-lead version of the popular .22, but the increasing variety of non-lead bullets for different firearms and applications is encouraging.

Conservation is a key aspect of the North American model of hunting, and hunting has played a major role in funding North American conservation (Heffelfinger et al. 2013, Geist et al. 2001). The examples of the voluntary programs in Arizona and the outreach efforts by biologists from the Yurok tribe suggest that if hunters are engaged in a collaborative way by informed people and peers who recognize the realistic costs and challenges to moving away from the use of lead in hunting ammunition, significant reductions in use of lead ammunition are possible. Statements by non-hunters that switching to non-lead ammunition is simple and incurs no additional economic burden do not match the experiences of all hunters, nor do they acknowledge the potentially high costs and time-consuming nature of such changes. Therefore, I argue that everyone concerned with this issue must be prepared to invest time, money, and expertise to working collaboratively with hunters and ammunition manufacturers to reduce the risk of lead exposure for wildlife and people from lead hunting ammunition. In turn, hunters should recognize and accept their duties as stewards and conservationists and work to embrace alternatives to lead ammunition when they are available.

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