animal wellness action

CENTER FOR A HUMANE ECONOMY

Lead Ammunition Imperils Wildlife, Hunting Families

Use of alternative forms of ammunition will remediate widespread lead poisoning problem.

DECEMBER 2025

Topline Concerns

- Millions of birds and mammals, especially scavengers and predators, suffer and die from lead poisoning after feeding on carcasses or gut piles left by hunters that are impregnated with toxic lead fragments
- Lead bullet fragments contaminate game carcasses and gut piles, posing health risks to hunters, their families, and food-insecure individuals who rely on soup kitchens and food pantries. Children and pregnant women are at the greatest risk from neurological, cardiovascular, and developmental damage by lead ammunition residues in game meat.
- Non-lead ammunition (including copper, steel, bismuth, tungsten, and metal alloys) provides strong ballistic performance and delivers equal or superior killing power at only marginal additional cost. This shields nontarget species, reduces human health risks from lead exposure, and aligns with conservation and public health goals.

I. Why is lead ammunition an issue?

Lead bullets, slugs, and shot for hunting manmals and birds have been used since the invention of firearms in the early 15th century. The popularity of lead ammunition is due to its historical use, low cost, and its ballistic properties as a soft but dense metal. However, lead (Pb) is a heavy metal with no safe level of exposure. Lead is toxic to all animals, including humans. Lead is even toxic to plants. Lead mining and manufacturing is a small industry that generates enormous harm. Lead impairs the growth, development, and reproduction of microbes, insects, plants, and animals.

Lead does not break down or biodegrade. The ingestion of even small quantities of lead can deliver a range of adverse health impacts to people, especially children, pregnant women, and unborn children.

- Lead is particularly damaging to the brain and the rest of nervous system. Lead can quickly reach the bloodstream when inhaled as dust, ingested, or consumed in water. Unlike most toxicants and pathogens, it can pass into the brain through the blood-brain barrier.
- Lead mimics calcium's properties so that it accumulates in bone and teeth and interrupts metabolic processes.
- In humans, lead reduces IQs and increases the risk of heart disease, kidney failure, and premature death. Women and children are particularly vulnerable as lead exposure can cause miscarriage, premature birth, and low birth weight.

As evidence of lead toxicity has accumulated over the past century, efforts have been made to limit anthropogenic sources of Pb in the environment. Some of these efforts were successful. For example, in most developed countries, lead was banned from gasoline, paint, water pipes, and various household items (such as children's toys and pottery).

The U.S. Fish and Wildlife Service banned lead shot for waterfowl hunting in 1991. Despite this conservation triumph and the rapid transition by waterfowl hunters to non-toxic ammunition, hunters pursuing other game, from squirrels to rabbits to deer, moose, elk, and black bears, still use lead ammunition nearly 35 years later.

Unlike lead in batteries or other in industrial uses, lead ammunition is used as projectiles and expelled directly into ecosystems, posing risks to wildlife and humans. Lead ammunition is now the greatest, unregulated source of lead that is knowingly discharged into our environment. The U.S. annually produces billions of rounds of ammunition, including rimfire and centerfire cartridges and shotshells. Hunters and target shooters annually discharges at least 50,000 tons of lead into our nation's environment. This is equivalent to about 9 billion .22 caliber bullets or ~180 million car batteries worth of lead. In fact, most lead ammunition is manufactured from recycled lead batteries.

For millions of Americans, game meat, especially from deer and elk, is an important source of animal protein. There are about 12 million deer hunters in the U.S., and their families, friends, and neighbors consume more than 6 million deer annually, according to the National Deer Association. While the exact percentage of deer killed with lead ammunition is not known, available research and agency reports suggest that more than 90% of deer in the U.S. killed by firearms are shot with lead-based bullets.

II. Lead ammo & human health: venison with a side of lead

Lead ammunition widely used in deer hunting across the United States poses significant threats to human health. When a lead bullet strikes an animal, it often fragments into hundreds to thousands of tiny particles that can disperse well beyond the wound channel. These fragments may remain in the meat, even after standard butchering and trimming. They are often small enough to be unknowingly ingested.

Studies have found elevated blood lead levels in people who frequently consume wild game harvested with lead ammunition, particularly children and pregnant women, for whom even low doses can impair neurological development, lower IQ, and cause long-term cognitive and behavioral deficits. For adults, chronic lead exposure increases the risk of cardiovascular disease, kidney damage, and reproductive problems. The U.S. Food and Drug Administration does not recognize a safe limit for lead in meat. Because there is no safe level of lead exposure, these risks are a public health concern wherever lead-based hunting ammunition is common.

Most rifle bullets used for large game hunting expand upon impact to ensure maximum deadly effect. Expanding high-velocity lead bullets fragment upon impact, producing large to microscopic fragments, especially in larger game animals. A single round can shatter into millions of smaller fragments up to 18 inches away from the bullet's trajectory, especially when it strikes bone in deer and elk. Many of the fragments in the animal's tissues are tiny microparticles that are too small to see with the naked eye or to feel or otherwise sense when eating. These fragments scatter into the muscle and entrails of hunted animals. For a venison consumer, these particles bioaccumulate over time and contribute to rising lead levels, with the attendant and well-documented array of neurological and other health risks. Although the FDA does not recognize a safe limit for the amount of lead in meat, the European Commission set maximum levels at 0.1 parts per million (ppm). Lead concentrations more than 100 times this limit have been detected in the meat of lead-shot carcasses as far as six inches from the entry wound.

Scientists have used X-rays, CT scans, and other imaging technologies to visualize and count sometimes hundreds of minute lead particles in hunted meat. Chemical analysis has also detected high concentrations of lead in hunted carcasses. Most lead shards are too small to be seen with the naked eye, and minuscule fragments (nanoparticles) are not detectable even by X-rays. The lead shards can also dissolve during digestion, poisoning the surrounding tissues. Both the fragments and the contaminated meat are poisonous when consumed. Recent research found that in deer and grouse samples, lead micro- and nanoparticles too small to be detected by standard medical radiography exceeded levels set by the U.S. Centers for Disease Control and Prevention for protection of human health.

A strong body of scientific research demonstrates that lead-based ammunition frequently contaminates hunted meat and increases blood lead levels of humans and animals who consume it.

- In 2008, the Minnesota Department of Natural Resources experimentally shot 80 deer and sheep carcasses and evaluated the presence of lead in each. High-velocity ballistic tip bullets left an average of 141 fragments in a mean of eleven inches from the wound channel; some were farther. Some fragments were too small to see with anything but a sensitive X-ray image. Lead ammunition fired from high-powered rifles contaminated carcasses more than slower-moving lead slugs fired from shotguns.

- A 2009 study of 30 deer harvested with lead bullets in Wyoming and processed by 22 different meat processors found an average of 136 lead fragments per deer; 32% of the burger packages had at least one metal fragment. Twenty percent of the packages had only one fragment, 7% had two fragments, and 5% had 3 to 8 fragments. Burger packages always have more lead fragments than steaks and roasts.
- The Minnesota Department of Agriculture tested 1,029 commercially ground burger packages using X-rays and found lead fragments in 26%. Lead was also found in 2% of 209 packages containing whole cuts of meat. (Ground meat is far more likely to show detectable fragments than intact cuts because fragments mix through the batch during grinding, so that more samples for testing will test positive for lead.) Also, the cuts that are ground are usually the shoulder and neck musculature, which are much more likely to be near the point of bullet impact than the loins and rumps, which are considered the primal cuts.
- In a 2008 Wisconsin study, researchers collected 183 packages of venison burgers from hunters' freezers, food pantries, and meat processors. They found that 15% of commercially processed burgers and 8% of hunter-ground packages were contaminated with lead.
- Ground venison packets from shotgun- and archery-harvested white-tailed deer in Illinois in 2013 and 2014 were analyzed for metal contamination. Radiographs indicated that 48% of twenty-seven ground venison packets from ten shotgun-harvested deer contained lead metal fragments, while none of the fifteen packets from three archery-harvested deer contained fragments.
- Multiple studies have found a direct link between game harvested with lead ammunition and spikes in blood lead. For example, in a 2009 North Dakota study with 736 participants, those who consumed wild game had higher blood lead levels than those who did not.

The 2025 PhD thesis of Annina Haase, "Food safety implications of metals from bullet fragments in game meat: An investigation of bullet composition, bullet fragmentation and gastrointestinal solubility," cites 308 references on lead fragments in game meat, the most comprehensive literature review of this topic ever published. The thesis highlights the need for greater policy consideration of the biological hazards from lead ammunition and fragmentation for game meat food safety, i.e., a regulatory focus beyond the environmental impacts of lead ammunition.

Not surprisingly, venison donated to food banks can also be contaminated with lead fragments from lead-based ammunition. Over 40 states operate game meat donation programs associated with food banks, facilitating the distribution of roughly 1 million kilograms (1,100 tons) of game meat annually (Buenz et al 2024). Most donated game meat is ground deer meat (venison), as well as wild hog and goose.

The proportion of donated ground venison packages containing detectable lead fragments is typically 10-25%. For example, the U.S. Department of Health and Human Services found that 15% of donated one-pound ground venison packages sampled from Wisconsin food banks contained visible lead fragments. From 2014 to 2019, the Minnesota Department of Agriculture found and discarded 9% of donated venison because of lead contamination observed via X-ray. This prevented more than 4,243 lb. of lead-adulterated venison from reaching Minnesota food banks. Donations of hunted meat from archery season and from animals killed with non-lead ammunition have extremely low levels of lead contamination.

Venison donation programs provide millions of meals to food banks across the country. States with venison donation programs include those that also harvest the most deer: Texas, Michigan, Pennsylvania, Wisconsin, and Georgia. None

of these five states require X-ray inspection of meat for lead contamination. Minnesota is the only state with mandatory screening of donated hunted meat for lead contamination. Some states, such as Iowa and South Dakota, put warning labels on donated venison stating that lead fragments may be present. This underlying lack of food safety standards for adulterated donated food increases risks to low-income recipients who are already disproportionately affected by elevated blood lead levels (BLLs).

III. Lead-linked losses: wildlife casualties in the wake of the hunt

Lead-based ammunition poses serious threats to wildlife, especially birds, and particularly avian or mammalian scavengers and predators that feed on carcasses or gut piles left in the field or directly ingest environmental spent lead bullets. Lead poisoning from ammunition also creates important global conservation problems for many wildlife species, especially raptors, including the highly endangered California condor. An estimated ten million to twenty million birds and other animals die each year from lead poisoning in the United States after ingesting lead left behind by hunters.

Lead poisoning is a leading cause of death in some raptor populations, causing paralysis, emaciation, reproductive failure, and death. A lead fragment the size of a grain of rice is lethal to a mature bald eagle, meaning that a standard 150-grain lead bullet can poison ten eagles. The deadly metal bioaccumulates in an eagle's system throughout their lives, causing long-term harm even at low exposure levels. Just as in humans, there is no safe amount of lead exposure. For this reason, lead is often called "the silent killer."

Slabe et al (2022) looked at lead levels in samples collected from 1,210 bald and golden eagles from 38 U.S. states across North America. They found that almost half of all animals sampled had chronic, toxic levels of lead (as measured in bone), and about a third of bald and golden eagles had acute Pb poisoning, as measured in liver, blood, and feathers. Demographic modeling suggested that these levels are high enough to suppress population growth in both species.

Mammalian predator scavengers, including foxes, coyotes, and bears, are similarly at risk from lead in spent ammunition, as are waterfowl who ingest spent lead shot from the ground or sediments. The problem is widespread and well-documented, with numerous studies showing that seasonal spikes in wildlife lead poisoning follow hunting seasons. Domestic animals, such as dogs and cattle, are also exposed to Pb through ammunition. Coyotes, wolves, and foxes are less likely to die from lead poisoning (as they pass Pb fragments more quickly through their digestive tract as compared to birds), but they can still suffer sublethal effects such as organ damage, neurological impairment, and immune suppression. Hunting dogs fed trimmings from lead-shot game have also been poisoned.

The ecosystem impacts of lead ammunition extend beyond individual wild animal deaths. The loss of top predators and scavengers can disrupt ecological balance, leading to cascading effects including increased carcass persistence, prey population changes, and altered nutrient cycling. In aquatic systems, lead bullets and shot can persist in sediments for decades, leaching into water and posing ongoing hazards to fish, amphibians, and aquatic invertebrates. Because lead is a persistent, bio-accumulative toxin, it can move up the food chain, magnifying exposure risks for both wildlife and humans who rely on hunting and fishing for subsistence.

IV. Lead-free ammunition is available and in wide use

Lead-free ammunition, including steel, copper, bismuth, and tungsten, is widely available and increasingly effective from both cost and lethality perspectives. Copper and copper-alloy bullets, for example, retain their weight, mushroom predictably on impact, and do not fragment into toxic particles, thereby eliminating the primary source of contamination.

Advances in bullet design have ensured that non-lead ammunition can approach or match the accuracy and lethality of lead rounds for deer hunting. The lethality of copper usually exceeds that of lead bullets in larger game. In a survey of manufacturers who produce both lead and non-lead ammunition in the same caliber, the non-lead rounds are usually 25-50% more expensive. That sounds like a lot, but so few rounds are fired on most hunting trips that the cost difference is negligible. Transition programs in several states and tribal areas have shown that voluntary or mandated shifts to non-lead ammunition can significantly reduce Pb exposure in both humans and wildlife within just a few hunting seasons.

Given the known health risks, the proven ecological harm, and the availability of safe, effective alternatives, phasing out lead ammunition in deer hunting is a practical and scientifically supported step toward protecting public health and sustaining healthy ecosystems. The reasons for switching to non-lead are numerous: excellent weight retention and penetration, consistent expansion, and less risk of lead fragments ending up on dinner plates and in the bellies of scavengers.

Hunters have touted the lethality of non-lead bullets for decades. Even the April 10, 2010, issue of the National Rifle Association's (NRA's) American Hunter Magazine wrote:

> "Every now and then a new bullet comes along that redefines what we think we know about hunting projectiles. The Barnes all-copper X-Bullet was one of those, and it has become the most imitated big-game bullet on the market. It was introduced in 1989, and ever since, the Barnes X has been a favorite of serious big game hunters wherever men take rifles into wild places."

Just as non-toxic alternatives have been available for waterfowl hunters for decades, there are readily available alternatives for big game hunting. Copper or brass bullets are available in virtually every rifle and handgun caliber. Copper or brass bullets' ballistics are similar to lead, while weight retention during penetration is usually superior. In fact, the U.S. military is transitioning to non-lead small arms ammunition under its "green ammunition" initiative.

Copper vs Lead Bullets

30 caliber Winchester magnum lead core with copper jacket
- Highly toxic
- Hundreds of fragments

30 caliber Winchester magnum solid copper bullet
- Non-toxic
- No fragmentation

https://www.usgs.gov/media/images/copper-and-lead-ammunition-comparison

V. Banning lead ammunition for hunting protects people and wildlife

In public health, primary prevention refers to actions taken before a disease or injury occurs to prevent it from happening in the first place. The successful American history of banning lead from paint (1977), plumbing for drinking water (1986), and gasoline (1996) in reducing lead levels in humans demonstrates the utility of the primary lead prevention approach. For example, following the lead ban from gasoline, blood lead levels in U.S. children decreased from 15.2 µg/dL in the late 1970s to 0.83 µg/dL by 2016. This reduction is associated with an average increase of 4-5 IQ points across the population.

Similarly, the nationwide ban on lead shot for waterfowl hunting in the United States, implemented in 1991, shows the benefits of banning lead ammunition. Prior to the lead ban for waterfowl hunting, an estimated 2,700 tons of shot were deposited in wetlands each year. This policy reduced lead ingestion among waterfowl by approximately 50%, preventing an estimated 1.4 million duck deaths annually.

A strong, multi-line evidence base shows that restricting or banning lead ammunition produces measurable wildlife and human-health benefits. These include:

- Large, measurable reductions in waterfowl lead poisoning and crippling occurred after lead-shot bans in 1991, as described above. Crippling (wounding) occurs when a hunter shoots an animal, but the animal is wounded and not immediately killed, allowing it to escape and die a slow and painful death from starvation, predation, or exposure. Whenever hunters are asked to transition away from the use of lead ammunition to mitigate lead's known risks to wildlife and people, hunters frequently cite concerns about the effectiveness of non-lead ammunition and how it will result in greater crippling rates and associated animal welfare costs. However, recent studies have found no differences in crippling rates using lead and steel ammunition. An Illinois study evaluated 37 years of waterfowl harvest data overlapping the mandated federal transition to non-lead shot for waterfowl hunting to assess how crippling rates changed following the ban. The authors (Ellis and Miller, 2022) reported, "The average crippling rate prior to the lead shot ban was 23% for both ducks and geese and reduced to an average of 15% and 11% for ducks and geese (respectively) following the ban. In addition, the annual trend in the proportion of ducks and geese crippled reversed following the ban, from a significant annually increasing to a significant annually decreasing trend."
- The recovery of the California condor from near extinction after lead ammunition was banned from its range shows that restricting lead ammunition reduces the pathways that poison scavengers and predators. Golden eagles and turkey vultures have also shown decreased lead exposure, indicating broader ecological benefits. Opponents of California's lead ammunition ban acknowledge that lead poisoning has historically hindered the recovery of the California condor. However, they argue that the species' resurgence can be attributed to intensive management efforts, such as captive breeding and veterinary care, rather than the elimination of lead ammunition.
- Human biomonitoring in Europe and North America links game consumption to higher blood lead, especially in frequent game meat consumers, so reducing ammunition-derived contamination reduces human exposure

and risk. Switching to non-lead bullets meaningfully lowers lead residues in edible tissues of game meat, reducing lead exposure in humans who consume it. There is some evidence that lead exposure from lead bullets may pose a higher risk of lead poisoning in humans compared to lead shot, primarily due to the greater fragmentation of lead bullets upon impact. Lead shot, commonly used in shotgun ammunition, consists of small pellets that are less likely to fragment into numerous tiny particles upon impact. However, the ingestion of even a single lead pellet can be harmful, particularly to children and pregnant individuals. If ingested with food, lead shot can become lodged in the appendix and release lead over time, commonly observed in people who regularly eat meat from wild fowl killed using lead shot.

- Regulation and policy: when governments require non-lead ammunition, benefits to human health and wildlife are expected. For example, California's lead ammunition ban has led to measurable health improvements in wildlife, particularly scavenger species like the California condor, and has reduced human exposure to lead through game meat consumption.

Several states have specific lead regulations beyond the federal waterfowl restrictions, many requiring non-toxic shot on certain management units or statewide. Waterfowl Production Areas and U.S. Fish and Wildlife Service refuges generally require non-toxic shot for hunting upland bird species because these areas are managed primarily for waterfowl and often contain numerous wetlands.

As of September 2025, California is the only U.S. state that has fully implemented a ban on lead ammunition for all hunting. This statewide prohibition began in 2019 and was phased in over several years, starting with restrictions in the California condor's range in 2007. Lawmakers in Maryland, Minnesota, New York, Maine, Oregon, and Washington have introduced legislation in recent years to prohibit the use of lead ammunition for hunting purposes or in certain areas, but these proposals have not been enacted into law.

At the federal level, while the U.S. Fish and Wildlife Service has announced plans to phase out the use of lead ammunition and/or fishing tackle on half a dozen national wildlife refuges by 2026, the agency continues to allow lead ammunition and tackle on the vast majority of refuges, even though the agency recognizes the adverse effects of lead on wildlife.

At certain other refuges, the U.S. Fish and Wildlife Service has initiated a voluntary lead-free pilot program. This project, extended for the 2025-2026 hunting season, offers rebates to hunters who voluntarily use lead-free ammunition on 13 national wildlife refuges across 11 states. The initiative aims to encourage the adoption of nonlead ammunition and reduce the risk of lead exposure to wildlife. Unfortunately, voluntary lead-free ammunition programs have shown limited effectiveness in reducing lead exposure among wildlife and humans. While they can foster collaboration and reduce conflict among stakeholders, their impact on hunting behavior and wildlife health has been minimal. They usually fail to achieve widespread compliance.

For example, a 2025 United Kingdom study found that 99% of pheasants and 100% of red grouse sampled were still killed with lead ammunition, despite a voluntary pledge by the UK's nine leading game shooting and rural organizations to phase out lead shot by 2025. "Because so many raptors were dying of plumbism (lead poisoning), Audubon of Kansas offered varminters nontoxic copper ammo at the same cost as cheaper lead bullets," wrote award-winning hunting writer Ted Williams in an essay describing large-scale target shooting of prairie dogs in the Sunflower State. "After four years, it didn't have a single taker. Varminters resist copper for no other reason than they've always used lead." In contrast, California's mandatory lead ammunition ban has led to measurable reductions in lead exposure among wildlife, such as California condors, golden eagles, and turkey vultures.

One reason for this failure to implement a hunting ammunition lead ban is the opposition from the firearms and ammunition interest groups and manufacturers. This includes the National Rifle Association (NRA), Gun Owners of America (GOA), Safari Club International (SCI), Congressional Sportsmen's Foundation (CSF), National Shooting Sports Foundation (NSSF), and firearm and ammunition manufacturers.

VI. Congress debates lead ammunition policy

In November 2025, U.S. Rep. Ted Lieu, D-Calif., introduced the Lead Endangers Animals Daily (LEAD) Act (H.R.6268) to phase out the use of lead ammunition on lands and waters under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). Senator Tammy Duckworth, D-Ill., previously introduced a similar bill, S.3852, in the 118th Congress. The bills aim to mitigate the risks of lead toxicosis in people and wildlife, including federally listed threatened and endangered species, particularly scavengers like bald eagles and California condors. The bills have not yet passed either chamber of Congress.

There is also an effort in Congress by lawmakers allied with the NRA to block federal agencies from restricting the use of lead ammunition on our federal lands. The Protecting Access for Hunters and Anglers Act of 2025, S.537 and H.R.556, introduced by Sen. Steve Daines, R-Mont., and Rep. Rob Wittman, R-Virg., aims to prevent federal agencies from banning lead ammunition or fishing tackle on federal lands unless there is unit-specific scientific evidence showing harm to wildlife populations and the regulation is approved by the relevant state. This legislation prioritizes recreational access and affordability for hunters and anglers, asserting that blanket federal bans are unnecessary and burdensome. Together, these bills reflect opposing philosophies and a sharp divide in federal policy approaches: one prioritizes environmental protection, the other emphasizes recreational access and state control.

X-rays of deer carcasses shot with lead bullet & copper bullet

- Bright white spots = lead fragments
- Spread throughout animal's body
- Contaminate meat & environment

- No copper bullet fragments

VII. Evolving USFWS views of lead ammunition for hunting on National Wildlife Refuges

The FWS operates hunting and sport fishing programs on wildlife refuges to implement Congressional directives to facilitate refuge-compatible priority wildlife-dependent recreational opportunities, including fishing and hunting. The recently (re)-introduced Lead Endangers Animals Daily (LEAD) Act (H.R.6268) proposes to phase out the use of lead ammunition on lands and waters under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). Specifically, the bill would "require the Secretary of the Interior to prohibit the use of lead ammunition on United States Fish and Wildlife Service lands."

The National Wildlife Refuge System of the USFWS manages 573 national wildlife refuges across all 50 U.S. states and territories. The FWS formally acknowledged in 2022 that "… the best available science and sound professional judgement … indicates that lead ammunition and tackle have negative impacts on both wildlife and human health." The agency further stated, "We disagree with the notion that there is insufficient scientific evidence to support regulatory requirements for hunters to use lead-free ammunition."

"While the Service continues to evaluate the future of lead use in hunting and fishing on Service lands and waters, we will work with stakeholders and the public to evaluate lead use through the annual rulemaking process. In the interim, the Service does not intend to allow opportunities increasing or authorizing the new use of lead on Service lands and waters."

Regarding the use or non-use of lead ammunition and fishing tackle, the USFWS utilized a dual approach: (1) applying lead restrictions on certain refuges (via station-specific rules) and (2) voluntary incentive-based programs to use non-lead ammo and tackle on others.

(1) *Refuge-by-refuge regulatory action for public use:* Instead of a comprehensive lead ammo or tackle system ban, the Service has been addressing lead use by the public on a refuge-specific basis through the annual station-specific hunting and sport-fishing rulemakings and signaling that broader lead-free adoption is a long-term goal. For example, the Service has put in place a lead-free ammunition requirement for newly opened elk hunting at four refuges in North Dakota.

(2) *Voluntary/incentive program approach:* USFWS is also running and expanding voluntary lead-free ammunition incentive pilots (rebates/outreach) at selected refuges as a non-regulatory pathway to reduce lead use while gathering data and stakeholder input. The program was piloted in 2024 and expanded for 2025-26. See U.S. Fish and Wildlife Service.

VIII. Conclusions

Lead ammunition remains one of the last widely tolerated sources of intentional lead release into the environment, despite overwhelming evidence of harm to wildlife, domestic animals, ecosystems, and human health. As this report demonstrates, lead-based hunting ammunition contaminates game meat, poisons scavengers and predators, disrupts ecological processes, and exposes millions of American hunters, their families, and food-insecure non-hunting communities who consume donated venison to unnecessary health risks. These impacts are well documented across multiple scientific disciplines and mirror the historical harms that led the United States to ban lead from gasoline, paint, plumbing, and other consumer products.

Conservation-minded hunters who are using lead ammunition or improperly disposing of animal remains may be uninformed about this issue, rather than indifferent to the deleterious impacts lead ammunition can have on non-target organisms. On the other hand, lead ammunition use continues among some hunters who are dismissive, unconvinced, or mistrustful of lead's dangers or who believe that non-lead ammunition campaigns are part of an anti-hunting agenda.

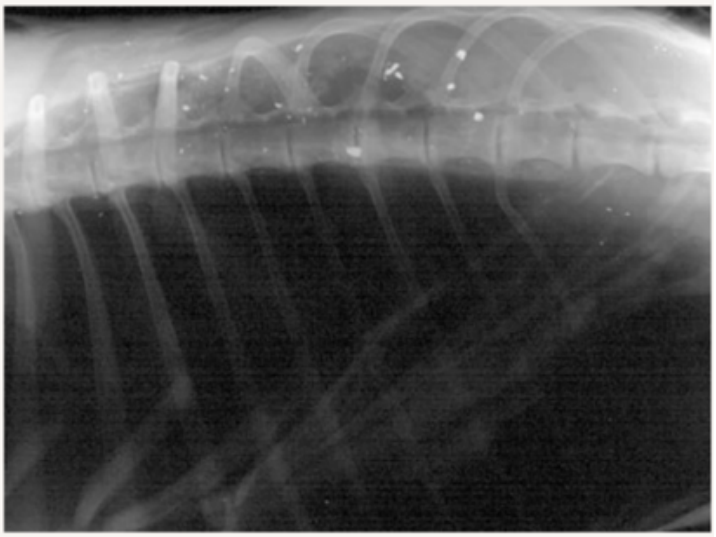
Crucially, these plumbism harms from lead ammunition are now avoidable. Safe, effective, and widely available non-lead ammunition alternatives now exist for virtually all hunting applications, offering comparable ballistic performance at modest additional cost. Where mandatory or well-designed transition programs have been implemented, reductions in lead exposure among wildlife and humans have followed within just a few hunting seasons. The continued use of lead ammunition is therefore not a technological necessity, but a policy and awareness failure.

Phasing out lead ammunition for hunting represents a clear opportunity for primary prevention by protecting wildlife, safeguarding public health, and sustaining ecosystems without compromising hunting effectiveness or tradition. Given the strength and consistency of the evidence, the continued discharge of lead into the environment through hunting is neither scientifically defensible nor ethically justified. Replacing lead ammunition with non-toxic alternatives is a practical, proven, and overdue step toward healthier humans, resilient wildlife populations, and functioning ecosystems. Given the failure of voluntary attempts to reduce hunting lead ammunition use, policies and laws tightly regulating and eventually banning lead ammunition at the state and federal levels will most likely result in the best health outcomes for hunters and their families, animals, and ecosystems.

Addendum of images

Traditional lead bullet fragmentation on entry

Copper bullet on entry showing zero fragmentation



X-ray showing presence of lead bullet fragments in deer backstrap.

An assortment of lead bullets showing shot fracturing next to similar fired copper variants

Images from https://huntingwithnonlead.org

The most common hunting bullet is a lead core with a copper jacket. When an animal is shot, millions of sub-microscopic bullet fragments are dispersed throughout the carcass. This fragmentation occurs regardless of where the animal is shot, but there is more lead fragmentation if the bullet strikes a hard material such as bone. Pb particles with small surface areas increase bioavailability and make detection more difficult.

According to industry estimates, about 95 percent of the 10 billion to 13 billion rounds of ammunition purchased every year in the United States contain lead, which primarily comes from recycled car batteries. These bullets are often jacketed by a harder metal like copper or steel (Urbina 2018).

Radiograph (X-ray) showing bullet fragmentation in a deer carcass. The “white spots” are bullet fragments. Many lead fragments are microscopic and are undetectable during butchering or when the venison is eaten.

https://ca.audubon.org/news/man-who-sounded-alarm-about-lead-ammunition-and-public-health

Figure from: Arnemo JM, 2022. “Lead ammunition used by hunters has us all in its sights.” Outreach, Inland Norway University of Applied Sciences.

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https://researchoutreach.org/wp-content/uploads/2023/06/Jon-M.-Arnemo_8em.pdf
Note: Jon Arnemo is a pro-hunting Norwegian veterinarian and lead ammunition expert. This short (four-page) paper is an excellent resource and very readable.

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"There is an urgent need to end a major source of lead for animals and humans: spent lead bullets and shotgun pellets. Notably, production of lead-based ammunition in the United States accounted for >69,000 metric tons consumed in 2012; this is second only to the amount of lead used to manufacture storage batteries. However, there are few regulations regarding the release of lead into the environment through discharge of lead-based ammunition. For other major categories of lead consumption, such as lead batteries and sheet lead/lead pipes, environmental discharge and disposal are regulated. Therefore, lead-based ammunition is the greatest largely unregulated source of lead that is knowingly discharged into the environment in the United States."

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Discusses history and trade-offs of lead vs cooper bullet used in hunting.
"Copper bullets fly plenty flat enough for the ranges most hunters actually shoot and perform wonderfully. If you have a choice, shoot 'em if you like 'em. If you don't have a choice, just understand how they work and why they're different from our traditional lead-core bullets.

Either way, you can use them with confidence — but not always with the exact same shots you'd consider for cup-and-core (copper jacketed lead) bullets."

Buenz E, 2016. Lead exposure through eating wild game. *American Journal of Medicine,* 128:458. https://www.amjmed.com/article/S0002-9343(16)30021-3/pdf

Buenz EJ, Parry GJ, 2018. Chronic lead intoxication from eating wild-harvested game. *American Journal of Medicine*. 131(5):e181-4. https://static1.squarespace.com/static/64d55b1bbed3ec770fdeb2fb/t/64dbeb3348e14001ce7507b5/1759522361652/2018

Buenz EJ, Parry GJ, Hunter S et al, 2024. X-ray screening of donated wild game is insufficient to protect children from lead exposure. *Discover Food*. 2024 May 24;4(1):31. https://link.springer.com/article/10.1007/s44187-024-00104-9

Collin S, Baskar A, Geevarghese DM et al, 2022. Bioaccumulation of lead (Pb) and its effects in plants: A review. *Journal of Hazardous Materials Letters*. 3:100064. https://www.sciencedirect.com/science/article/pii/S266691102200017X
"The uptake of lead by the primary producers (plants) is found to affect their metabolic functions, growth, and photosynthetic activity. The accumulation of lead in excess can cause up to a 42% reduction in the growth of the roots. … Pb has no biological purpose in plants, although it can create morphological, physiological, and biochemical problems."

Dobrowolska A, Melosik M, 2008. Bullet-derived lead in tissues of the wild boar (Sus scrofa) and red deer (Cervus elaphus). Eur J Wildl Res 54, 231–235 (2008). ttps://doi.org/10.1007/s10344-007-0134-y

Doyle, Michael, "Feds avoid lead ammo showdown in refuge hunting proposals." *E&ENews*. May 21, 2025. https://www.eenews.net/articles/feds-avoid-lead-ammo-showdown-in-refuge-hunting-proposals/

Ellis MB, Miller CA, 2022. The effect of a ban on the use of lead ammunition for waterfowl hunting on duck and goose crippling rates in Illinois. *Wildlife Biology*. Mar;2022(2):e01001. https://nsojournals.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/wlb3.01001
One of the only papers that scientifically examines crippling (wounding) during hunting with lead shot vs steel (non-lead) shot. Crippling declined with the ban of lead shot for waterfowl hunting in 1991 and the start of steel shot.

Finkelstein ME, Doak DF, George D et al, 2012. Lead poisoning and the deceptive recovery of the critically endangered California condor. *Proceedings of the National Academy of Sciences*. 109(28):11449-54. https://www.pnas.org/doi/pdf/10.1073/pnas.1203141109

Gremse F, Krone O, Thamm M et al, 2014. Performance of lead-free versus lead-based hunting ammunition in ballistic soap. *PLoS One*. 9(7):e102015. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0102015

Haase A, Sen M, Gremse C et al, 2023. Analysis of number, size, and spatial distribution of rifle bullet-derived lead fragments in hunted roe deer using computed tomography. *Discover Food*. 3(1):11. https://link.springer.com/content/pdf/10.1007/s44187-023-00052-w.pdf
"The use of lead-based rifle bullets in hunting poses a risk to human and animal health when

bullet fragments remain in the game meat. The objective of this study was to assess, for the first time, the number, size, and spatial distribution of bullet fragments in game animals collectively and in three dimensions using CT."

Haase A, 2025. Food safety implications of metals from bullet fragments in game meat: An investigation of bullet composition, bullet fragmentation, and gastrointestinal solubility. Doctoral thesis, *Technische Universität Berlin*. https://doi.org/10.14279/depositonce-23948

Summary of the state of knowledge of lead in game meat.

This is the most comprehensive literature review on bullet fragments in game meat; cites 308 references of this topic ever published; 308 references cited.
"Despite the extensive data on the toxicity of lead (Pb), game meat represents one of the last uncontrolled sources of Pb exposure for humans. Conflicts of interest among different hunting stakeholders slow the implementation of legal measures to restrict the use of Pb in rifle bullets. ... This thesis aimed to systematically investigate the food safety implications of the use of Pb-based and alternative hunting rifle bullets through a multi-stage approach across primary production, meat processing, and game meat at the consumer level."

Hampton JO, Bengsen AJ, Flesch JS et al, 2022. A comparison of lead-based and lead-free bullets for shooting sambar deer (Cervus unicolor) in Australia. Wildlife Research. 50(9):632-641. https://connectsci.au/wr/article/50/9/632%20/41231/A-comparison-of-lead-based-and-lead-free-bullets

Høgåsen HR, Ørnsrud R, Knutsen HK et al, 2016. Lead intoxication in dogs: risk assessment of feeding dogs trimmings of lead-shot game. BMC Vet Res 12, 152. https://doi.org/10.1186/s12917-016-0771-z

Hunt WG, Watson RT, Oaks JL et al, 2009. Lead bullet fragments in venison from rifle-killed deer: potential for human dietary exposure. *PLoS One*. 4(4):e5330. https://pmc.ncbi.nlm.nih.gov/articles/PMC2669501/
"We conclude that people risk exposure to bioavailable lead from bullet fragments when they eat venison from deer killed with standard lead-based rifle bullets and processed under normal procedures. At risk in the U.S. are some ten million hunters, their families, and low-income beneficiaries of venison donations."

Hydeskov HB, Arnemo JM, Lloyd Mills C et al, 2024. A global systematic review of lead (Pb) exposure and its health effects in wild mammals. *Journal of Wildlife Diseases*. 60(2):285-297. https://meridian.allenpress.com/jwd/article-abstract/60/2/285/498936

Summary of the state of knowledge of lead poisoning of wild mammals.

A global systematic literature review to identify peer-reviewed studies published on Pb exposure in wild mammalian species and the health effects they identified. In total, 183 studies, conducted in 35 countries and published over 62 years (1961-2022), were included in this review.

Iqbal S, Blumenthal W, Kennedy C et al, 2009. Hunting with lead: association between blood lead levels and wild game consumption. *Environmental Research*. 109(8):952-959. https://www.sciencedirect.com/science/article/abs/pii/S0013935109001467

Katzner TE, Pain DJ, McTee M et al, 2024. Lead poisoning of raptors: state of the science and cross-discipline mitigation options for a global problem. *Biological Reviews*. 99(5):1672-1699.

https://www.researchgate.net/profile/Guillermo-Wiemeyer/publication/380290446_Lead_poisoning_of_raptors_state_of_the_science_and_cross-discipline_mitigation_options_for_a_global_problem/links/6748c98f790d154bf9b3288f/Lead-poisoning-of-raptors-state-of-the-science-and-cross-discipline-mitigation-options-for-a-global-problem.pdf

Summary of the state of knowledge of lead poisoning of raptors.

Kelly TR, Bloom PH, Torres SG et al, 2011. Impact of the California lead ammunition ban on reducing lead exposure in golden eagles and turkey vultures. PLoS One. 6(4):e17656. https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0017656&type=printable

Kemmerling LR, Darst AL, Adabag M et al, 2025. Lead (Pb) concentrations across 22 species of butterflies correlate with soil and air lead and decreased wing size in an urban field study. Science of The Total Environment. 15;969:178900. https://www.sciencedirect.com/science/article/pii/S0048969725005352

Legagneux P, Suffice P, Messier J-S et al, 2014. High risk of lead contamination for scavengers in an area with high moose hunting success. *PLoS ONE* 9(11):e111546. https://doi.org/10.1371/journal.pone.0111546

Leontowich AF, Panahifar A, Chen S et al, 2025. Lead micro-and nanoparticles directly observed within gunshot wounds in hunted game meat. *Scientific Reports*. 2025 Oct 17; 15(1):36364. https://www.nature.com/articles/s41598-025-20285-2.pdf

Luby SP, Forsyth JE, Fatmi Z et al, 2024. Removing lead from the global economy. *The Lancet Planetary Health*. 8(11):e966-72. https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(24)00244-4.pdf
" The annual human costs of lead exposure include 5·5 million premature adult deaths from cardiovascular disease and US$1.4 trillion in losses to the global economy from lead impairing children's cognitive development... Millions of metric tonnes of lead are dispersed into the environment each year... Substitutes for lead in the economy are available and we should act in the best interests of the planet and human health by eliminating lead from the global economy by 2035."
" No rational deliberation about the use of lead-based ammunition can ignore the overwhelming evidence for the toxic effects of lead, or that the discharge of lead bullets and shot into the environment poses significant risks of lead exposure to humans and wildlife. Given the availability of non-lead ammunition for shooting and hunting, the use of lead-based ammunition that introduces lead into the environment can be reduced and eventually eliminated. This seems to be a reasonable and equitable action to protect the health of humans and wildlife."

McCarthy, Rachel. "Researchers find lead contamination in shotgun-harvested deer." *Illinois Wesleyan University*. Oct. 21, 2020. https://www.iwu.edu/news/2020/researchers-find-lead-contamination-in-shotgun-harvested-deer.html

McFarland MJ, Hauer ME, Reuben A, 2022. Half of US population exposed to adverse lead levels in early childhood. *Proceedings of the National Academy of Sciences*. 119(11):e2118631119. https://www.pnas.org/doi/full/10.1073/pnas.2118631119?trk=public_post_comment-text

McTee, Mike and Ellis, Corey. "Making the switch: a quick guide to going non-lead." Backcountry Journal. Nov. 7, 2022 https://www.backcountryhunters.org/making_the_switch_a_quick_guide_to_going_non_lead

Note: Includes a list of common non-lead ammunition options.
"Now, over 30 years after the first copper bullets began spiraling down rifle bores, hunters can find non-lead projectiles that will topple animals from prairie dogs to cape buffalo. Some bullets even deliver bone-shattering performance to 600 yards and beyond … The reasons for switching to non-lead are numerous: excellent weight retention and penetration, consistent expansion, and less risk of lead fragments ending up on dinner plates and in the bellies of scavengers. … Making the switch makes changing ammunition sound like a bigger deal than it usually is. For most hunters who shoot typical distances with a common cartridge, it's as simple as buying a box of non-lead ammunition, sighting in, and then going hunting. … The cost of non-lead has come down in recent years as the overall cost of ammunition has gone up."

McTee M, Kean B, Pons A et al, 2023. The seasonal threat of lead exposure in bald eagles. *Science of the Total Environment*. 889:164256.
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Note: Excellent x-ray images of condors with ingested lead bullets, lead fragments in meat, and lead fragmentation.

National Wildlife Refuge System; *2024-2025 Station-Specific Hunting and Sport Fishing Regulations*. U.S. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 32, Nov 7, 2024. 271 pp.
https://www.fws.gov/sites/default/files/federal_register_document/2024-25905.pdf

North American Non-Lead Partnership. A collaborative effort involving state wildlife agencies, conservation organizations, and sports groups. Promotes non-lead ammunition among hunters and anglers in North America
https://nonleadpartnership.org/media/en

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Pain DJ, Mateo R, Green RE, 2019. Effects of lead from ammunition on birds and other wildlife: A review and update. *Ambio*. 48(9):935-53.
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Rattner BA, Franson JC, Sheffield SR et al, 2008. Sources and implications of lead ammunition and fishing tackle on natural resources. *Wildlife Society Technical Review* 08-01 June 2008. The Wildlife Society, Bethesda, Maryland, USA.
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While authored by The Wildlife Society and the American Fisheries Society and other scientists (i.e., not directly an FWS-authored report), FWS repeatedly cites this 68-page technical review as *the best single compilation of science on lead ammunition impacts* in its rulemaking and planning documents.

Schulz JH, Stanis SA, Morgan M et al, 2021. Perspectives from natural resource professionals: attitudes on lead ammunition risks and use of nonlead ammunition. *Journal of Outdoor Recreation and Tourism*. 33:100341.
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Discusses the human health risks from hunted game meat donated to food banks across the United States

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