

**PETITION TO THE  
ENVIRONMENTAL PROTECTION AGENCY  
TO REGULATE LEAD BULLETS AND SHOT UNDER  
THE TOXIC SUBSTANCES CONTROL ACT**



Bald eagle suffering from lead poisoning. Photo courtesy The Raptor Center, University of Minnesota

**PETITIONERS**

CENTER FOR BIOLOGICAL DIVERSITY  
CORNELL LABORATORY OF ORNITHOLOGY  
PROJECT GUTPILE  
LOON PRESERVATION COMMITTEE  
THE TRUMPETER SWAN SOCIETY  
AMERICAN EAGLE FOUNDATION  
***AND 95 OTHER ORGANIZATIONS***

**PETITION FOR RULEMAKING UNDER THE TOXIC SUBSTANCES CONTROL ACT**

**March 13, 2012**

## **EXECUTIVE SUMMARY**

Pursuant to the Toxic Substances Control Act (“TSCA”), 15 U.S.C. § 2601 *et seq.*, the 101 petitioning organizations herein formally petition the Environmental Protection Agency (“EPA”) to initiate a proceeding for the issuance of a rule under Section 6 of TSCA to regulate bullets and shot containing lead used in hunting and shooting sports (such as target and skeet shooting), which have the potential to cause harmful lead exposure to wildlife and humans. The petitioners request a rulemaking which adequately protects against the unreasonable risk of injury to the environment and human health posed by toxic lead bullets and shot. Although the petitioners advocate for a rule implementing a nationwide ban on the use of bullets and shot containing lead for use in hunting and shooting sports, with explicit exceptions for military and law enforcement uses, the petitioners also request that the EPA evaluate and consider a range of alternatives that could eliminate the potential for harmful lead exposure to wildlife and humans.

Based on information extending back to Roman times more than 2,000 years ago, lead has long been identified as a highly toxic substance with lethal properties and numerous pathological effects on living organisms. Health effects from lead exposure can run the gamut from acute, paralytic poisoning and seizures to subtle, long-term mental impairment, miscarriage and impotence. Lead is a cumulative metabolic poison affecting a large number of biological functions including reproduction, growth, development, behavior and survival. Even low levels of exposure to lead can cause neurological damage, and there may be no safe level of lead in the body tissues of fetuses and young. Despite this knowledge, lead continues to be used in manufactured products, many of which are sources of toxic lead exposure to wildlife and to human beings.

In recent decades the federal government has begun to implement long-overdue regulations to reduce the exposure of humans to lead in drinking water, paint, gasoline, toys, toxic dumps, lead wheel balancing weights and both indoor and outdoor shooting ranges. Strict recycling regulations have been imposed on disposal of lead-acid batteries. However, spent lead ammunition is uncontrolled and lead remains widely encountered and distributed in the environment from hunting and sport shooting sources. The continued use of lead bullets and shot exposes any animal that preys or scavenges on targeted wildlife to lead’s toxic effects. Particularly susceptible are avian scavengers that encounter lead in carcasses left in the wild, in gut piles (viscera) from animals cleaned in the wild, and in wounded prey species that survive hunting and carry lead bullets, shot or fragments in their bodies. Sensitive wildlife such as bald and golden eagles and endangered California condors are frequently killed by lead poisoning or suffer chronic sublethal effects of lead poisoning from scavenging meat containing lead fragments from ammunition. Another source of significant lead exposure is from spent lead shotgun pellets, which accumulate in both aquatic and terrestrial habitats, where animals encounter and ingest them, often mistaking them for food, grit or bone fragments. More than 130 species of animals (including mammals, upland birds, raptors, waterfowl, amphibians and reptiles) have been reported in scientific literature as being exposed or

killed by ingesting lead shot, bullets, bullet fragments or prey contaminated with lead ammunition.

Ducks, geese and swans have received protection from hunting sources of lead poisoning since 1991 by a federal requirement to use only non-lead shot for hunting waterfowl, but similar restrictions in terrestrial habitats are scattered and localized. Data show that over 75 terrestrial species of birds are known to be poisoned by spent lead from ammunition. Mourning doves are particularly susceptible to ingesting lead shot pellets, and lead poisoning may kill as many as 20 million doves per year in the United States.

Ammunition manufacturers now market a wide variety of non-lead or less toxic bullets and shotgun pellets that can replace lead projectiles. There is no technological or commercial reason why non-lead ammunition with comparable effectiveness should not be substituted for the lead counterparts. Several states have mandated non-lead shotgun ammunition for upland game bird hunting. Those states with only a partial ban, such as California's requirement for big game hunting with non-lead ammunition within the eight-county range of California condors, continue to have high rates of lead poisoning in wildlife.

The EPA has long held that whenever a toxic substance customarily used in the manufacture of commercial products can be replaced by a nontoxic or less toxic substitute, articles made of the toxic substance should be removed from the market. All ammunition containing lead could economically be replaced with effective, non-lead alternatives that are nontoxic or less toxic, thus making a strong argument for EPA regulatory action.

TSCA grants the EPA the broad authority to regulate chemical substances that "present an unreasonable risk of injury to health or the environment" (15 U.S.C. § 2061). The EPA may regulate the manufacture, processing, distribution, use or disposal of such chemical substances. Specific control mechanisms include: prohibitions on an entire or certain use of a chemical substance; limitations on allowable concentration levels; labeling or recordkeeping requirements; and obligations to issue notice of risks of injury (15 U.S.C. § 2605(a)). The EPA has already declared that lead is a toxic substance, and has removed nearly all products containing lead from the market. Regulations to address the unreasonable risk of injury to human health or the environment from toxic lead shot and bullets may be achieved through a range of alternatives, up to and including the EPA prohibiting the manufacture, processing, or distribution in commerce of a lead for a particular use (15 U.S.C. § 2605(a)(2)(A)(i)). Although the EPA is specifically prohibited from regulating ammunition or firearms under TSCA, the toxic components of ammunition can be regulated if nontoxic or less toxic alternatives are commercially available. This petition is clearly not an attempt to regulate ammunition or firearms, but rather the toxic components of lead ammunition for which non-lead and nontoxic or less toxic alternatives have become widely available.

This petition differs from a TSCA petition submitted to the EPA in 2010 seeking a complete ban on all lead ammunition. The current petition seeks different relief under

TSCA, asking the EPA to initiate a rulemaking for regulations that adequately protect wildlife, human health and the environment against the unreasonable risk of injury from bullets and shot containing lead used in hunting and shooting sports, which have the potential to cause harmful lead exposure to wildlife and humans. This current petition is brought by a different and much larger group of petitioners. The petition introduces significant new information regarding the toxic effects of lead ammunition on wildlife, the toxic effects of lead on human health, the availability and performance of alternatives to lead ammunition, and the effectiveness of lead ammunition regulations.

This petition also provides significant new information repudiating the EPA's conclusion that TSCA does not provide the agency with authority to address lead shot and bullets. In denying the 2010 TSCA petition, the EPA stated that "TSCA does not provide the agency with authority to address lead shot and bullets as requested in your petition, due to the exclusion found in TSCA § 3(2)(B)(v)." However, the plain language of TSCA, as well as the Senate and House reports on the legislative history and intent of TSCA, runs counter to the EPA's interpretation that the agency lacks regulatory authority. According to the House report on the history and intent of TSCA, "the Committee does not exclude from regulation under [TSCA] chemical components of ammunition which could be hazardous because of their chemical properties."

States that have mandated non-lead ammunition requirements for specific hunting activities have active hunting communities that have successfully transitioned away from lead products. Market forces in these states have caused a full line of non-lead replacement products to be made available to the public, demonstrating that commercially available alternatives exist and the economic consequences of removing lead from the environment can be minimal. The EPA is compelled under TSCA to grant this petition and initiate a proceeding for the issuance of a rule under Section 6 to develop regulations to protect wildlife, human health and the environment from unreasonable risk of lead poisoning from lead ammunition.

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## 1. PETITIONERS AND STANDING TO FILE

Section 21 of the Toxic Substances Control Act (“TSCA” or the “Act”, 15 U.S.C. § 2601 *et seq.*) provides that “any person” may petition the Environmental Protection Agency Administrator (“EPA”) to initiate a proceeding for the “issuance, amendment, or repeal of a rule” (15 U.S.C. § 2620(b)(3)). Petitioners therefore have standing to petition the EPA to initiate proceedings to regulate lead shot and bullets under section 2605 of TSCA.

Lead petitioner Center for Biological Diversity is a non-profit organization that works to protect endangered species and wild places through science, policy, education, citizen activism, and environmental law. The Center has an ongoing interest in protecting wildlife from lead poisoning. Since 2004, the Center has taken action through a “Get the Lead Out” campaign to change policies regulating lead to prevent toxic lead from entering the food chain and has been a leading proponent of federal regulations on lead ammunition to protect endangered California condors, bald and golden eagles, and other wildlife species at risk from lead poisoning.

Petitioner Adirondack Wildlife is a nonprofit rehabilitation and education organization, working with local veterinarians and volunteers, whose mission is to take in, rehabilitate and, whenever possible, return to the wild, injured or otherwise disabled wildlife.

Petitioner Alabama Ornithological Society works to foster a greater knowledge of birds and to promote conservation of all natural resources.

Petitioner Alameda Creek Alliance is a California nonprofit conservation organization that works to protect and restore the natural ecosystems of the Alameda Creek watershed.

Petitioner American Eagle Foundation is a nonprofit organization of concerned citizens and professionals founded in 1985 to develop and conduct bald eagle and environmental recovery programs in the United States and to assist private, state and federal projects that do the same.

Petitioner Arizona Zoological Society is a nonprofit organization engaged in the conservation of wildlife and habitat, and operates the Phoenix Zoo as a zoological garden and recreation destination that engenders affection for and appreciation of nature.

Petitioner Arroyo Colorado Audubon Society is a South Texas organization working to promote an understanding of the unique and important natural habitats of the Lower Rio Grande Valley, the birds and other wildlife they support, and their benefits to humans.

Petitioner Ascutney Mountain Audubon Society in Vermont works to promote the enjoyment, appreciation, and conservation of nature through education, habitat protection and advocacy for the benefit of our communities and all living things.

Petitioner Audubon Nebraska works to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity.

Petitioner Audubon Society of New Hampshire is a statewide nonprofit organization dedicated to protecting New Hampshire's environment through active programs in environmental education, conservation science, land protection, and advocacy.

Petitioner Badger Run Wildlife Rehab is a nonprofit organization in Oregon dedicated to the care and treatment of injured and orphaned wildlife.

Petitioner Biodiversity Conservation Alliance is a nonprofit organization dedicated to protecting wildlife and wild places in Wyoming and surrounding states, primarily on public lands.

Petitioner Bird Conservation Network is a coalition of 18 organizations with an interest in the conservation of birds in northeast Illinois, southern Wisconsin and northwestern Indiana.

Petitioner Blue Ridge Wildlife Center is a non-profit wildlife conservation organization located in Virginia that rehabilitates injured, orphaned, and sick native wildlife, and monitors health threats to wildlife populations.

Petitioner Brainerd Lakes Area Audubon Society is an independent chapter of the Audubon Society that advocates for conservation and restoration of bird populations and other wildlife and their habitat, encourages grassroots action on conservation issues, and develops and implements educational programs, with special emphasis on the aquatic resources of the great Brainerd Lakes Area.

Petitioner Braveheart Raptor Rehabilitation Center is a nonprofit organization in Michigan involved in rehabilitation of injured and sick raptors, as well public education.

Petitioner Bridgerland Audubon Society is a Northern Utah chapter of the Audubon Society that works to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity.

Petitioner Carolina Raptor Center is dedicated to environmental stewardship and the conservation of birds of prey through education, research, and the rehabilitation of injured and orphaned raptors.

Petitioner Cascades Raptor Center is a nonprofit nature center and wildlife hospital in Oregon that works to foster a connection between people and birds of prey through wildlife rehabilitation and public education.

Petitioner Cascadia Wildlands works to protect and restore Cascadia's wild ecosystems as well as protect the most threatened wild places and wildlife from Oregon to Alaska.

Petitioner Center for Sierra Nevada Conservation is a nonprofit organization in California that works for sound management of our public lands and wise government land use policies.

Petitioner Clean Economy Coalition of Corpus Christi is a group of concerned citizens in and around the Corpus Christi region in Texas concerned with pollution from existing and proposed energy and industrial facilities.

Petitioner CORALations is a nonprofit conservation organization based in Puerto Rico.

Petitioner Cornell Laboratory of Ornithology is a world leader in the study, appreciation, and conservation of birds. The laboratory, founded in 1915, is a non-profit, membership-supported academic center within Cornell University, working to advance the understanding of nature and to engage people of all ages in learning about birds and protecting the planet.

Petitioner Delaware Valley Ornithological Club is an organization for birders and bird enthusiasts in the Delaware Valley region of Pennsylvania.

Petitioner Eagle Valley Raptor Center is a Kansas nonprofit organization that provides food, shelter and vet care for injured and orphaned Kansas birds of prey so they may return back to the wild. The Center also conducts guided educational tours and offers offsite programs to teach the important role these birds play in our environment.

Petitioner Elisha Mitchell Audubon Society is a North Carolina chapter of the Audubon Society that works to promote awareness and appreciation of nature, preserve and protect wildlife and natural ecosystems, and encourage responsible environmental stewardship.

Petitioner Endangered Habitats League is a nonprofit organization dedicated to the protection of the diverse ecosystems of Southern California and to sensitive and sustainable land use for the benefit of all the region's inhabitants.

Petitioner Environmental Action Committee of West Marin is a California nonprofit grassroots group working to protect West Marin's natural environment and rural character.

Petitioner Four Harbors Audubon Society is a New York chapter of the Audubon Society that advocates for education and conservation efforts for the enjoyment, preservation and restoration of birds, wildlife and habitat in Long Island communities.

Petitioner Freedom Center for Wildlife is a nonprofit organization working to increase public knowledge and appreciation for conservation, protection and preservation of native New Jersey habitats and animals through rehabilitation, education, and research programs.



Petitioner Friends of Dyke Marsh is a volunteer group dedicated to preserving and enhancing Dyke Marsh, the last enduring substantial freshwater tidal marsh in the Washington, D.C. area.

Petitioner Friends of Living Oregon Waters works to protect Oregon waters through public oversight, legal education, and field monitoring.

Petitioner Golden Gate Audubon Society is an independent, nonprofit organization dedicated to protecting birds, other wildlife, and their natural habitats in the San Francisco Bay Area.

Petitioner Grand Canyon Wildlands Council is an Arizona organization that works to create and apply a dynamic conservation area network that ensures the existence, health, and sustainability of all native species and natural ecosystems in the Grand Canyon ecoregion.

Petitioner Gratiot Lake Conservancy is a nonprofit organization working to conserve and protect Gratiot Lake and the land within the Gratiot Lake watershed in the Upper Peninsula of Michigan.

Petitioner Great Old Broads for Wilderness is a national organization that uses the voices and activism of elders to preserve and protect wilderness and wild lands. Conceived by older women who love wilderness, it gives voice to the millions of older Americans who want to protect their public lands as wilderness for this and future generations.

Petitioner Great Salt Lake Audubon is a nonprofit environmental organization affiliated with the National Audubon Society, dedicated to protecting and enhancing habitat for wild birds, animals and plants, and to maintaining healthy and diverse environments for wildlife and people throughout Utah.

Petitioner Hawk Mountain Sanctuary Association is a non-profit raptor conservation organization that runs a wildlife sanctuary, scientific research center, international conservation training site and learning facility in Pennsylvania.

Petitioner Hilton Pond Center for Piedmont Natural History works to conserve plants, animals, habitats, and other natural components of the Piedmont Region of the eastern United States through observation, scientific study, and education for students of all ages. The Center also conducts research on migrant birds that breed in the Piedmont and overwinter in the Neotropics and seeks to protect birds and their habitats along and on both ends of their migratory routes.

Petitioner Houston Audubon Society is a Texas chapter of National Audubon Society working to promote the conservation and appreciation of birds and wildlife habitat.

Petitioner Howard County Bird Club is a local chapter of the Maryland Ornithological Society, a nonprofit organization that works to educate people about avifauna and related

habitat; preserve, restore, and improve habitat for birds; and help collect and develop scientifically useful records and data.

Petitioner Indian Peaks Group of the Sierra Club is part of the Rocky Mountain Chapter of the Sierra Club, with a mission to explore, enjoy and protect the planet.

Petitioner Indigenous Youth Foundation is a California Native American cultural and environmental non-profit organization that works to preserve, restore and distribute Chumash culture. The Chumash people have lived for centuries in the condor range and have a long history of interaction with the California condor for a variety of purposes, including religious and ceremonial, and have a strong cultural interest in the recovery of the California condor.

Petitioner International Wildlife Rehabilitation Council is a nonprofit organization dedicated to providing science-based education and information to promote wildlife conservation and welfare worldwide.

Petitioner Iowa Association of Naturalists is a professional organization that promotes the development of skills and education within the art of interpreting natural and cultural resources. IAN members are planting the seed of environmental stewardship by communicating the meanings and relationships of the natural world.

Petitioner Jayhawk Audubon Society works to encourage enjoyment, promote understanding and advocate conservation of the natural world.

Petitioner Juniata Valley Audubon Society is a Pennsylvania chapter of the National Audubon Society dedicated to the conservation and restoration of natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the Earth's biological diversity.

Petitioner Kittitas Audubon Society is a chapter of the Audubon Society serving the communities of Kittitas County, Washington, working to develop an appreciation of nature through education and conservation with a focus on birds.

Petitioner Lahontan Audubon Society is a Nevada chapter of Audubon Society that seeks to help restore, preserve, and improve habitat for birds and other wildlife and to provide education about birds and their habitats in Nevada.

Petitioner Lane County Audubon Society is an Oregon chapter of the Audubon Society and a non-profit organization dedicated to the conservation of and education about our natural environment, with a primary focus on birds, other wildlife, and their habitats.

Petitioner Lehigh Valley Audubon Society has a mission to help people gain an appreciation and understanding of the natural world around them, to provide educational services on local wildlife to our community, and protect local habitats that are critical to local wildlife populations.

Petitioner Loon Lake Loon Association is a nonprofit organization concerned about the common loon in the Pacific Northwest. The association works to protect the common loon, preserve their habitat and educate the public.

Petitioner Loon Preservation Committee works to restore and maintain a healthy population of loons throughout New Hampshire, monitor the health and productivity of loon populations as sentinels of environmental quality, and promote a greater understanding of loons and the larger natural world.

Petitioner LoonWatch is a program of the Sigurd Olson Environmental Institute that protects common loons and their aquatic habitats in Wisconsin and the Upper Great Lakes region through education, monitoring, and research.

Petitioner Los Padres Forest Watch is a community-based nonprofit organization that is leading efforts to protect the Los Padres National Forest and other public lands along California's Central Coast.

Petitioner Madison Audubon Society is a Wisconsin Audubon chapter that educates about the natural world and threats that natural systems are facing, engages in advocacy to preserve and protect these systems, and develops and maintains sanctuaries to save and restore habitat.

Petitioner Maricopa Audubon Society is an Arizona chapter of the Audubon Society dedicated to the protection of the natural world through public education and advocacy for the wiser use and preservation of land, water, air, and other irreplaceable natural resources.

Petitioner Marin Audubon Society is a California chapter of the Audubon Society that works to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats, for the benefit of humanity and the Earth's biological diversity.

Petitioner Maryland Ornithological Society is a state-wide nonprofit organization devoted to the study and conservation of birds. Maryland Ornithological Society maintains a system of sanctuaries to encourage the conservation of birds and bird habitat, and helps record and publish observations of bird life.

Petitioner Mobile Bay Audubon Society is an Alabama chapter of the Audubon Society working to promote the conservation of Earth's biological diversity by encouraging an appreciation of birds and other wildlife, along with an understanding of the ecological requirements necessary for their survival.

Petitioner Monmouth County Audubon Society's mission is to promote the awareness, appreciation and conservation of natural resources through activism and educational outreach and by representing the National Audubon Society in Monmouth County, New Jersey.

Petitioner New York City Audubon is a independent non-profit organization affiliated with the National Audubon Society, working to protect wild birds and habitat in the 30,000 acres of wetlands, forests, and grasslands of New York City.

Petitioner Northcoast Environmental Center is a non-profit organization whose mission is to promote understanding of the relations between people and the biosphere and to conserve, protect, and celebrate terrestrial, aquatic, and marine ecosystems of northern California and southern Oregon.

Petitioner Ojai Raptor Center is a southern California organization dedicated to the rehabilitation and release of injured and orphaned wildlife and to the education through non-releasable birds of prey to educate the public and community about native wildlife.

Petitioner Orange County Audubon Society is a New York chapter of the national Audubon Society that manages 400 acres of wildlife sanctuaries.

Petitioner Palouse Audubon Society is a nonprofit organization raising public awareness about wild birds and their habitat needs in the Palouse region of North Central Idaho and Eastern Washington.

Petitioner Prairie Dog Pals is a New Mexico organization dedicated to the preservation of the species in the region. Prairie Dog Pals does field work during the rescue season to relocate Gunnison's prairie dogs to safe habitat, sustain urban colonies at risk, and perform educational outreach to groups, classrooms, and individuals.

Petitioner Preserve Our Wildlife is a Florida organization dedicated to the protection and defense of all wild animal species, to the conservation of their natural habitats, and to the education of people about these imperative needs.

Petitioner Project Gutpile is an educational organization comprised of hunters/wildlife biologists and anglers that provides educational resources for sportsmen about lead-free hunting and angling. Project Gutpile has been promoting non-lead ammunition and raising awareness about lead in the hunting community since 2002.

Petitioner Raptor Education Group is an organization dedicated to caring for injured or orphaned native bird species, public education on wildlife issues and research on captive behavior, nutrition, husbandry and disease of native avian species.

Petitioner Raptor Services, LLC is a Wisconsin-based consulting firm providing data for private and public agencies during the permitting and mitigation process required for land development.

Petitioner Rio Grande Chapter of the Sierra Club is comprised of five local groups working to protect the air, land and water throughout New Mexico and West Texas.

Petitioner Rocky Mountain Chapter of the Sierra Club is comprised of nine local groups working to protect the air, land and water throughout Colorado.

Petitioner Rocky Mountain Wild is a nonprofit conservation organization working to protect, connect and restore wildlife and wild lands in the greater Southern Rockies ecoregion of Colorado, southern Wyoming, and eastern Utah.

Petitioner Rogue Valley Audubon Society is a chapter of the National Audubon Society and is a leading voice for birding, nature education, and habitat conservation in southern Oregon.

Petitioner Santa Clara Valley Audubon Society in California works to preserve, enjoy, restore and foster public awareness of native birds and their ecosystems.

Petitioner Sequoia Audubon Society protects native birds and other wildlife and their ecosystems in San Mateo County, California by engaging people of all ages in conservation, education, advocacy and enjoyment.

Petitioner Stream Systems is a San Francisco Bay area research and development company that works closely with government agencies from around the world involved in environmental protection and home land security, offering technical and engineering skills in all disciplines. Stream Systems produces an official testing device used by the U.S. Fish and Wildlife Service and other game officers to aid in the differentiation of lead to non-toxic shot in shotgun shells.

Petitioner Tennessee Ornithological Society is an independent, non-profit, educational and scientific organization devoted to the study and conservation of birds.

Petitioner Teton Raptor Center is an organization of conservation biologists, veterinarians, wildlife rehabilitators, educators, and volunteers working to help birds of prey and promote environmental health through educational programs, conservation initiatives, medical treatment and rehabilitation.

Petitioner The Lands Council is a grassroots nonprofit organization in Washington dedicated to protecting the quality of life in the Inland Northwest.

Petitioner The Trumpeter Swan Society is a non-profit organization based in Minnesota dedicated to assuring the vitality and welfare of wild Trumpeter Swan populations throughout North America.

Petitioner Ventana Wilderness Alliance works to protect, preserve and restore the wilderness qualities and biodiversity of the public lands within California's Northern Santa Lucia Mountains and Big Sur coast.

Petitioner Wachiska Audubon Society is a Nebraska chapter of the Audubon Society that works to preserve and restore native grasslands and other natural ecosystems, promote

birding, support native wildlife, provide educational opportunities and advocate on behalf of our natural environment and sustainability.

Petitioner Walden's Puddle is a wildlife rehabilitation and education center that provides care and treatment to more than 2,400 sick, injured and orphaned native Tennessee wild animals annually.

Petitioner Western Cuyahoga Audubon Society is a nonprofit organization in Ohio that works to educate the public about conservation of the natural world.

Petitioner Western Nebraska Resources Council is a non-profit dedicated to preserving the quality of watersheds and native biomes while maintaining the lifestyle of Western Nebraska, accomplished through educating the public and policy makers and hands-on work.

Petitioner Western Wildlife Conservancy is a non-profit organization in Utah that works to protect wildlife and wildlife habitat in the Intermountain West through research, education and advocacy.

Petitioner White Mountain Conservation League is an Arizona nonprofit organization dedicated to sustaining and enhancing the White Mountain ecosystems and communities.

Petitioner WildCare is a California organization that advocates for wildlife for a sustainable world by offering a wide array of programs to help people live well with wildlife. WildCare runs a wildlife hospital and environmental education programs.

Petitioner WildEarth Guardians is a New Mexico nonprofit organization that works to protect and restore the wild places, wildlife and wild rivers of the American West.

Petitioner Wild Equity Institute is a California nonprofit organization that unites the grassroots conservation and environmental justice movements in campaigns that build a healthy and sustainable global community for people and the plants and animals that accompany us on Earth.

Petitioner Wild Heritage Planners, based in Southern California, collaborates with government, industry, and stakeholders as urban planners, transportation advocates, and environmental sustainability consultants, advocating for smart growth and comprehensive planning solutions to pressing issues challenging urban and regional development, energy, and climate stability.

Petitioner Wild Wings, Inc. is a nonprofit educational organization in New York that houses and cares for permanently injured birds of prey which are unable to survive on their own in the wild any more.

Petitioner Wild Wings (Old Greenwich) is a nonprofit, all-volunteer, wildlife rehabilitation and environmental education organization in Connecticut dedicated to the preservation and well-being of wildlife and habitats.

Petitioner Wild Wings Raptor Rehabilitation is a non-profit center that provides emergency medical and restorative care to wild native raptor species in Oregon.

Petitioner Wildlife Center of the North Coast is a nonprofit wildlife center that provides rehabilitative care to native wildlife in the central and north Oregon coast and southwest Washington, offers conservation education programs to the region and conducts non-lethal research in wildlife and environmental health.

Petitioner Wisconsin Audubon Council represents and combines the efforts of 15 Audubon chapters, two Audubon nature centers, and Audubon members in Wisconsin. The promotes the conservation, preservation and study of all wildlife, plants, soil, water, air, and other natural resources for the benefit of nature and society.

Petitioner Wisconsin Metro Audubon Society works to inform the public and encourage wise environmental practices through education and conservation, working toward a future when children and adults will respect, appreciate, and protect the environment.

Petitioner Zumbro Valley Audubon Society is a Minnesota chapter of the Audubon Society that brings environmental awareness, appreciation, and advocacy to the community.

TSCA requires that within 90 days after the filing of a petition, the EPA shall either grant or deny the petition (15 U.S.C. § 2620(b)(3)). If the Administrator grants the petition, the Administrator shall promptly commence an appropriate proceeding. If the Administrator denies the petition, the Administrator shall publish in the Federal Register the Administrator's reasons for such denial (15 U.S.C. § 2620(b)(3)).

Contact information for petitioners:

Center for Biological Diversity  
351 California Street, Suite 600  
San Francisco, CA 94104  
Contact: Jeff Miller  
Phone: (415) 436-9682 x303  
E-mail: [jmiller@biologicaldiversity.org](mailto:jmiller@biologicaldiversity.org)

## II. NATURE OF THE REQUESTED REGULATION

Petitioners request that the EPA initiate a rulemaking to regulate bullets and shot containing lead used in hunting and shooting sports, pursuant to TSCA (15 U.S.C. § 2605(a)(2)(A)(i)). Such regulations are needed to protect vulnerable wildlife species from the ongoing threat of lead poisoning, as well as to safeguard human health. Petitioners believe the necessary and most effective regulation would be a complete ban on bullets and shot containing lead for use in hunting and shooting sports, with specific exceptions for military and law enforcement uses, but also request that the EPA evaluate and consider a range of alternatives to eliminate the potential for harmful lead exposure to wildlife and humans. Petitioners request a rulemaking pursuant to section 6(a) of TSCA.

TSCA grants the EPA broad authority to regulate chemical substances that “present an unreasonable risk of injury to health or the environment” (15 U.S.C. § 2061). The EPA may regulate the manufacture, processing, distribution, use or disposal of such chemical substances. Specific control mechanisms include: prohibitions on an entire or certain use of a chemical substance; limitations on allowable concentration levels; labeling or recordkeeping requirements; and obligations to issue notice of risks of injury (15 U.S.C. § 2605(a)). Regulations to address toxic lead shot and bullets which present an unreasonable risk of injury to human health or the environment may be achieved through a range of alternatives, up to and including the EPA prohibiting the manufacture, processing, or distribution in commerce of a chemical substance for a particular use (15 U.S.C. § 2605(a)(2)(A)(i)).

TSCA mandates that the EPA must regulate chemical substances where there is a “reasonable basis to conclude” that such substances “present an unreasonable risk of injury to health and or the environment” (15 U.S.C. § 2605(a)). Lead used in shot and bullets is a “chemical substance” falling within the scope of TSCA. As defined by TSCA, “Except as provided in subparagraph (B), the term ‘chemical substance’ means any organic or inorganic substance of a particular molecular identity, including (i) any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature and (ii) any element or uncombined radical” (15 U.S.C. § 2602(2)(A)).

The EPA has already declared that lead is a toxic substance, and has removed nearly all products containing lead from the market. Most other uses of lead, such as lead-based paints, plumbing pipe and fixtures, and leaded gasoline, are already subject to strict regulation (15 U.S.C. §§ 2681-2692). The EPA has recently initiated additional regulatory actions to reduce lead exposure, for example: lead and lead compounds were added to the Priority Testing List (40 C.F.R. 716.120; *see also* 15 U.S.C. § 2603(e)), requiring certain lead manufacturers to submit unpublished health and safety reports to the EPA (73 Fed. Reg. 5109-5115; Jan. 29, 2008); lead automobile wheel balancing weights will be phased out with an EPA proposed rule; EPA recently solicited comments on a petition to phase out the largest remaining permitted use of leaded gasoline, that for piston-driven aircraft (USEPA 2010); and manufacturers of consumer products intended for use by children who also manufacture lead or lead compounds are required to report



certain health and safety data to the EPA. However, the EPA currently does not regulate the manufacture, processing, distribution, use or disposal of lead in shot or bullets under TSCA.

### **III. PREVIOUS EFFORTS TO REGULATE**

On August 3, 2010, the American Bird Conservancy, Association of Avian Veterinarians, Center for Biological Diversity, Project Gutpile and Public Employees for Environmental Responsibility submitted a petition to the EPA under TSCA requesting that the EPA issue a proposed rule to prohibit the manufacture, processing, and distribution in commerce in the United States of lead ammunition (including bullets and shotgun pellets) and lead fishing tackle. The EPA denied the petitioners' request for a ban on lead shot and bullets in a letter dated August 27, 2010. The EPA stated in its letter that "EPA has determined that TSCA does not provide the Agency with authority to address lead shot and bullets as requested in your petition, due to the exclusion found in TSCA § 3(2)(B)(v). Consequently, we are denying that portion of your petition."

EPA's denial of the petition notwithstanding, TSCA does in fact provide the EPA with the authority to address lead shot and bullets. While certain substances are excluded from the definition of "chemical substances," the exclusion found in TSCA § 3(2)(B)(v) does not apply to lead shot or bullets. See the discussion in section VI below, Authority to Act.

This current petition before the EPA seeks different relief under TSCA than the 2010 petition, is brought by a different group of petitioners, and introduces new information. This petition provides information repudiating EPA's conclusion that TSCA does not provide the agency with authority to address lead shot and bullets.

This petition does not seek a ban of all lead ammunition used in hunting and shooting sports. It instead asks the EPA to initiate a rulemaking for regulations that adequately protect wildlife, human health and the environment against the unreasonable risk of injury from bullets and shot containing lead used in hunting and shooting sports, which have the potential to cause harmful lead exposure to wildlife and humans. Although the petitioners advocate for a nationwide ban on the use of bullets and shot containing lead for use in hunting and shooting sports, with explicit exceptions for military and law enforcement uses, the EPA has latitude under TSCA to consider a broad range of alternatives for addressing an unreasonable risk of injury and the petitioners request that the EPA evaluate and consider a range of alternatives that could eliminate the potential for harmful lead exposure to wildlife and humans. In doing so, it is EPA's responsibility to determine the least burdensome alternative that adequately addresses the unreasonable risk of injury.

## **IV. REASON FOR THE REQUEST**

### **A. Introduction**

Lead has been used by humankind for millennia. Lead had numerous uses in ancient Egypt and it is believed that toxicity arising from the use of lead in water pipes, pottery, cosmetics, food and wine may have contributed to the fall of the Roman Empire (Hernberg 2000). The properties of lead as a biocide have been well known for hundreds of years. It is now unquestioned scientific knowledge that lead is a toxic substance with potentially lethal as well as numerous pathological effects on living organisms of all sorts. Despite this knowledge, lead has continued to be used in a wide variety of manufactured products, many of which are continued sources of toxic lead exposure to humans and to wildlife.

The use of lead for hunting dates back hundreds of years. The effects of lead in modern shot and bullets on wildlife have been well documented and reviewed (e.g. Pain 1992; Fisher et al. 2006; Rattner et al. 2007). Recognizing these threats, some jurisdictions began placing restrictions on the use of lead ammunition in the 1970s and 1980s. Despite minimal restrictions, significant amounts of lead continue to be deposited in aquatic and upland habitats and enter the food chain from spent lead ammunition. Legal and illegal hunting using lead ammunition may directly or secondarily expose wildlife to lead and deposit bioavailable lead into the environment. Shooting sports such as skeet/trap shooting and target practice activities also deposit significant amounts of lead in geographically localized areas.

Lead can remain in the environment relatively intact and stable for decades, and, under some environmental conditions it can be readily released and taken up by plants or animals (ATSDR 2007). Absorbed or ingested lead can cause a range of biochemical, physiological, and behavioral effects in species of invertebrates, fish, amphibians, reptiles, birds, and mammals. Wildlife can be exposed to lead through feeding in aquatic environments and ingesting contaminated vegetation and sediments, feeding on invertebrates or vertebrates containing lead, or ingesting lead pellets or fragments directly, mistaking them for food, grit, or bone. Although lead is a naturally occurring metal in the environment, for biological systems it is a nonessential metal with no functional or beneficial role at the molecular or cellular level. Ingested lead substitutes in dysfunctional ways for calcium in biochemical interactions, with harmful effects on neurological functions, bone structure, renal function, reproductive functions, pancreatic functions, and muscular functions, among others.

Lead is toxic to organisms at very low levels, and has lethal and severe sublethal effects at higher levels (IPCS 1989; Nordic Council of Ministers 2003). Lead can act as a neurotoxin, and numerous studies indicate that blood lead concentrations even below 10 micrograms per deciliter can have adverse developmental effects on intellectual functioning and social-behavioral conduct in humans (Needleman et al. 1990; Canfield et al. 2003; Ris et al. 2004). Human fetuses and young children are particularly sensitive to even low levels of lead exposure and can easily suffer permanent neurological damage.

Clinicians now assert that there is no safe level of lead in the body tissues for fetuses and young children (e.g. Canfield et al. 2003; Lanphear et al. 2005, 2006; Carlisle et al. 2009).

In recent decades the federal government has taken various regulatory actions to reduce the exposure of humans to lead in drinking water, paint, gasoline, toys, toxic dumps, automobile wheel balancing weights, and indoor and outdoor shooting ranges. However, other lead sources causing significant contamination are still uncontrolled, and lead exposure to wildlife has been widely documented and is not adequately regulated.

Toxic lead shotgun pellets from hunting accumulate in both aquatic and terrestrial habitats, where animals often eat them because they are mistaken for grit or food (seeds). Birds frequently ingest spent lead shotgun pellets as grit normally consumed to aid grinding of foods in the gizzard during digestion. Spent lead shotgun pellets on the ground in fields where upland game birds are hunted are also ingested by birds as grit making herbivorous birds as well as carnivorous birds victims of lead poisoning. Mourning doves are particularly sensitive to this, as they are hunted in fields where they congregate to feed, and spent lead pellets are the appropriate sized grit for doves. Ducks, geese, and swans have received much protection from this source of lead poisoning since 1991 through the federal requirement to use only non-lead shot for hunting waterfowl, but similar restrictions in terrestrial habitats are few, scattered, and localized. Research has shown that over 75 terrestrial species of birds are known to be poisoned by spent lead ammunition (Eisler 1988; Fisher et al. 2006).

Evidence has accumulated over the past century and it is now incontrovertible fact that lead fragments in the bodies of animals shot with lead bullets or lead shotgun pellets are a serious source of lead exposure to scavenging animals that eat meat containing lead fragments and residue (e.g. Calvert 1876; Holland 1882; Grinnell 1894; Bowles 1908; Pain 1992; Fisher et al. 2006; Rattner et al. 2007). Lead fragments in meat also pose potential health risks to humans who eat lead-tainted game, especially subsistence hunters dependent upon hunted game for food. Critically endangered California condors, bald and golden eagles, ravens, and other scavenging birds are frequently killed or harmed by this source of lead poisoning.

More than 130 species of animals (including upland birds, raptors, waterfowl, mammals and reptiles) have been documented being exposed or killed by ingesting lead shot, bullets, bullet fragments or prey contaminated with lead ammunition (Environment Canada 1995; Tranel and Kimmel 2009). As long as ammunition manufactured with lead projectiles remains available for purchase and use, numerous species of wildlife will continue to be poisoned by lead and human health will be threatened, posing an unreasonable risk of injury to human health and the environment.

## **B. Sources and Quantities of Lead in the Environment from Hunting and Shooting Sports**

The density of spent lead shot in wetlands or fields is related to hunting intensity. In waterfowl hunting areas, prior to the national requirement for non-lead shot, densities of spent shot from about 50,000 pellets to over 2 million pellets per acre were reported (Bellrose 1959; Pain 1992; Rocke et al. 1997). Areas with regular hunting from fixed position blinds or pits resulted in significant accumulation of spent lead. Prior to the banning of lead shot for waterfowl hunting, an estimated 2,721 metric tons of spent lead shot were deposited in U.S. wetlands each year (Pain 1992), and spent shot accumulated near the surface of sediments in aquatic settings, increasing the amount of lead shot available to waterfowl over time (Pain 1992). The depth of lead fragments in soil and their availability are influenced by land management practices such as cultivation, and lead shot and bullets can persist for decades to hundreds of years (Fredrickson et al. 1977; Jorgensen and Willems 1987; Kendall et al. 1996).

Despite the ban on lead shot for waterfowl hunting, significant lead shot deposition continues today in upland fields used for hunting, where densities of spent lead shot can reach over 400,000 pellets per acre (Schulz et al. 2002). Castrale (1989) estimated densities of 11,000 pellets/acre in a field managed for dove hunting in Indiana. Lewis and Legler (1968) estimated 43,600 pellets/acre in a field managed for dove hunting in Tennessee. Esslinger and Klimstra (1983) estimated 44,000 pellets/acre in a field managed for goose hunting in Illinois. Fredrickson et al. (1977) estimated 122,800 pellets/acre in uncultivated fields near duck blinds in Missouri. Best et al. (1992a) estimated 344,000 pellets/acre in an area frequented by dove and quail hunters in New Mexico. The Washington Fish and Wildlife Nontoxic Shot Working Group in 2001 estimated densities of 188,000 and 344,000 pellets/acre at two pheasant release sites in Washington.

Large amounts of spent lead ammunition also continue to be deposited in the environment through hunting of big game, upland species, furbearers, and from predator control activities (Scheuhammer and Norris 1995; Schulz et al. 2002). Lead from shot, bullets and bullet fragments in tissue or entrails of wounded or dead animals has been increasingly recognized as a threat to many scavenging species (Jannsen et al. 1986; Hunt et al. 2006; Knopper et al. 2006).

To give an idea of the quantity of potentially lead-tainted carcasses available to scavengers, Fry and Maurer (2003) quantified hunter-shot carcasses available to condors in their California range before the California lead ammunition ban went into effect, and concluded that gut piles and whole carcasses left in the field by hunters were a highly significant source of lead within the condor range. From hunting survey data for the eight counties encompassing the condor range in California, Fry and Maurer (2003) estimated an annual average of 36,000 big game animals (17,000 wild pigs, 11,000 coyotes and 8,000 deer) were taken each year by sport hunters in this area. Fry and Maurer (2003) assumed that only a very few gut piles are actually buried, hidden successfully, or removed from the field. Deer and pigs are generally field dressed and gut piles discarded

in the field; coyotes are generally left in the field intact. The Fry and Maurer (2003) figures do not account for poaching, which likely significantly increases the number of deer carcasses available. The data also do not account for the thousands of pigs and deer shot by ranchers under depredation permits or small game such as ground squirrels shot by varmint hunters. The carcasses of large animals left in the field would be the primary source of hunter-shot food for condors, although condors and other scavengers will eat smaller animals as well. Fry and Maurer (2003) estimated that almost 28,000 tree squirrel, rabbit, and ground squirrel carcasses are left in the field within the condor range annually. Even animals as small as ground squirrels shot with .22 caliber bullets can contain lead fragments at biologically relevant levels that may constitute a lead-hazard for other scavenging birds of prey (Harmata and Restani 1995; Knopper et al. 2006).

Target, trap and skeet shooting can result in substantial accumulation of spent lead in localized areas, and lead from spent shot at shooting ranges can become bioavailable to terrestrial and aquatic plants, invertebrates, and vertebrates (Scheuhammer and Norris 1995). Individual shooting ranges can deposit as much as from 1.4 to 15 tons of lead shot and bullets each year; estimates of the annual amount of lead shot and bullets deposited at the roughly 9,000 outdoor shooting ranges in the U.S. range from 72,600 to 80,000 metric tons (Tanskanen et al. 1991; USEPA 2001; Craig et al. 2002; USGS 2008). Kendall et al. (1996) estimated mean densities of spent lead shot at trap, skeet, and sporting clay ranges in the United States at 3.7 billion pellets/acre. Large concentrations of lead at shooting ranges (up to 17,000 grams per square meter) cluster in small areas because of stationary targets, trajectories of launched targets, and concentration of shooters (Darling and Thomas 2003). Significant amounts of fine particulate lead can concentrate near shooting stations.

Studies of the dissolution of lead from shot at terrestrial shooting ranges suggest that one-half of a lead shot pellet would release into the soil within 40 to 70 years and that the entire lead shot would transform in 100 to 300 years, with mechanical disturbance of soil enhancing transformation rates (Jorgensen and Willems 1987; Scheuhammer and Norris 1995; Hardison et al. 2004). Lead concentrations in soil at shooting ranges have been shown to be up to 55,000 mg/kg, over 10,000 times background levels (Scheuhammer and Norris 1995). Lead leaching into soil or sediment exceeding criteria for hazardous waste and dissolved lead entering surface water and ground water exceeding water quality criteria has been documented at many U.S. shooting ranges (Murray et al. 1997; Bruell et al. 1999; Craig et al. 1999; Rooney et al. 1999; Chen et al. 2002; Cao et al. 2003a, 2003b; Soeder and Miller 2003; Sorvai et al. 2006). One study of shooting ranges over water showed high shot density in the soil/sediment fall zone and lead concentrations in water samples two orders of magnitude above EPA water quality criteria (Stansley et al. 1992).

### **C. Pathways of Lead Exposure**

Lead has been widely dispersed throughout the environment from activities such as mining, smelting, manufacturing, and engine combustion. Many historical documented instances of lead exposure among terrestrial wildlife species have been associated with

small contaminated areas, such as around metal smelters, shooting ranges, lead paint contaminated buildings, or locations with intense hunting pressure (Blus et al. 1991, Henny et al. 1991; Blus et al. 1995; Sileo et al. 2001; Lewis et al. 2001). Manufacture and uses of leaded gasoline, lead-based paints and pesticides, and use of lead solder in cans has now been nearly eliminated in the U.S. Environmental distribution of lead from hunting and shooting however, is still widespread, although it is difficult to estimate the magnitude of lead exposure compared to other sources, such as legacy residues of leaded gasoline exhaust deposition, emissions from smelters, improper disposal of paint chips and dust, and lead ground to dust from lead wheel weights falling off vehicles.

Lead from shot, bullets and fragments in heavily hunted fields, wetlands, and shooting areas can be directly ingested or solubilized and biologically incorporated into food items (Ma 1989; Stansley and Roscoe 1996; Hui 2002). Studies at shooting ranges have shown increased lead levels in terrestrial and aquatic plants (Manninen and Tanskaenen 1993; Peterson et al. 2003; Mellor and McCartney 1994; Rooney et al. 1999; Hui 2002), and lead concentrations in invertebrates have been shown to be elevated due to uptake of lead near shooting ranges (Hui 2002; Labare et al. 2004).

There is very little information on lead released from spent shot aquatic habitats which could be solubilized and taken up by invertebrates or fish (Stansley et al. 1992; Hui 2002). For reptiles and amphibians near heavily hunted wetlands and shooting ranges, consumption of waterborne lead and ingestion of lead-contaminated sediments and food items are likely exposure pathways (Stansley and Roscoe 1996; Borkowski 1997; Camus et al. 1998; Hammerton et al. 2003; Pattee and Pain 2003; Lance et al. 2006). There is extensive documentation of direct ingestion of lead shot and bullet fragments by dabbling and diving ducks, swans, loons and other water birds, and other marsh birds feeding in wetland areas that are hunted with lead ammunition can ingest spent lead, such as flamingoes, rails, shorebirds, terns and herons (Artman and Martin 1975; Kaiser et al. 1980; Maedgen et al. 1982; Custer and Mulhern 1983; Hall and Fisher 1985; Locke et al. 1991; Beck 1997; Mateo et al. 1997; Acora 2005).

The most significant lead exposures and effects are due to direct ingestion of spent lead shot and bullet fragments by waterfowl (Sanderson and Bellrose 1986) and certain upland game species (Kendall et al. 1996, Schulz et al. 2006). Secondary poisoning of birds consuming wounded or dead prey contaminated with lead ammunition and scavenging of gut piles with spent lead ammunition or fragments is a significant source of toxic exposure to predatory and scavenging birds, with particularly deadly effects on bald eagles and California condors (Pattee and Hennes 1983; Kramer and Redig 1997; Meretsky et al. 2000; Church et al. 2006; Hunt et al. 2006; Pauli and Buskirk 2007). The recent use of stable lead isotope ratios has provided evidence that ammunition sources are responsible for lead exposure in wild birds (Scheuhammer and Templeton 1998; Scheuhammer et al. 2003a; Church et al. 2006, Finkelstein et al. 2010).

Granivorous (seed-eating) bird species may ingest lead shot as grit, or perhaps mistaking it for berries, which may be similar in appearance after drying and falling (Calvert 1876; Campbell 1950; Hunter and Rosen 1965; Fimreite 1984; Best 1992; Scheuhammer et al.

1999; Lewis et al. 2001; Potts 2004; Butler 2005a, 2005b; Rodrigue et al. 2005). Significant lead exposure has been documented in doves foraging at intensive hunting or target-shooting areas (Fisher et al. 2006 Schulz et al. 2002). Species that forage primarily on seeds on the ground may have higher risk, but even bird species with very different foraging strategies, such as woodpeckers, can acquire lead - presumably by ingesting lead fragments embedded in trees or on the ground (Mörner and Peterson 1999). Of birds and mammals examined in a firearm shooting field, 33% were found to have elevated lead tissue levels and 17% to have potential subclinical or clinical lead exposure (Lewis et al. 2001). Deer are thought to ingest lead fragments on the ground at shooting ranges because of the taste of lead salts on oxidized fragment surfaces (Lewis et al. 2001).

Animals that scavenge hunter-killed carcasses are at the highest risk of encountering severely toxic concentrations of lead. Recent studies by Hunt et al. (2006, 2009) evaluated radiographic evidence of lead fragments in 38 deer killed by licensed hunters using center fire rifles with lead-based copper jacketed, soft point bullets in Arizona from 2002 to 2004. Ninety-four percent of samples of deer killed with lead-based bullets contained fragments and 18 out of 20 (90%) offal piles contained lead fragments. Metal fragments were found to be broadly distributed along wound channels. The authors concluded that the data demonstrated a high potential for scavenger exposure to lead. Meanwhile, the carcasses and gut piles from deer killed by non-lead copper expanding bullets (or “Xbullets”) showed little evidence of fragmentation (Hunt et al. 2006, 2009).

Reports from experimental and field observations conclude that all bird species would be susceptible to lead poisoning after ingesting and retaining shot in the gastrointestinal system (Fisher et al. 2006). Raptor and scavenger species that feed on animals killed with lead ammunition would be at high risk for exposure to lead in this way. Animals that consume lead particles that have fragmented in hunter-killed carcasses may be at particular risk because the small size and irregular shape of fragments make them more absorbable in the digestive process.

Fisher et al. (2006) listed fifty-nine terrestrial bird species worldwide that have been exposed to lead from ammunition sources, including raptors, galliforms, gruiforms, columbiforms, and gulls. Vyas et al. (2000, 2001) identified lead in song birds resident on a shotgun trap and skeet range. Fisher et al. (2006) reviewed published literature on lead poisoning of 32 species of wild birds in the United States from spent lead ammunition. Documented cases of ingestion and poisoning by lead from ammunition in terrestrial birds globally include 33 raptor species and 30 species from *Gruiformes*, *Galliformes* and various other avian taxa, including ten globally threatened or near threatened species (Pain et al. 2009). Lead poisoning is of particular conservation concern in long-lived slow breeding species, especially those with initially small populations. A review by the Minnesota Department of Natural Resources found over 130 species of animals (including upland birds, raptors, waterfowl, and reptiles) have been reported in scientific literature as being exposed or killed by ingesting lead shot, bullets, bullet fragments or prey contaminated with lead ammunition (Tranel and Kimmel 2009). In the United States, Kendall et al. (1996) found that upland game birds ingest substantial amounts of lead shotgun pellets and deduced that raptors must incur secondary ingestion of pellets



because their prey ingested it. Rifle-shot prairie dogs and ground squirrels may contain fragmented lead particles that could be ingested by scavengers or raptors (Knopper et al. 2006; Pauli and Buskirk 2007). Kramer and Redig (1997) compiled data on more than 2,000 bald eagles, demonstrating that lead shot pellets, likely from crippled waterfowl and lead fragments in offal and unrecovered deer carcasses, were responsible for elevated lead levels in more than 98% of birds admitted to a veterinary hospital and raptor center. Recent studies have definitively linked isotopically labeled lead in California condors with rifle bullets sold in the same region, substantiating the claims that condors are ingesting lead from hunting sources and that condor lead poisoning deaths and sublethal effects are solely from lead bullet fragments (Scheuhammer et al. 2003a; Church et al. 2006; Chesley et al. 2009; Finkelstein et al. 2010).

Terrestrial birds are exposed to lead mainly through ingestion. Galliforms and doves probably ingest spent shot as grit which is retained in their gizzards, although there is considerable uncertainty as to why doves ingest shot pellets (Schulz et al. 2002). Approximately 2.5% of hunter-shot doves examined contained lead shot in their digestive system, giving a rough estimate of the proportion of doves that ingest shot (Schulz et al. 2002). A similar percentage of doves collected on fields where hunters used steel shot ingested steel shot (Schulz et al. 2002). Estimates of the U.S. dove population are 350-600 million birds (Dunks et al. 1982; Schulz et al. 2006), and experimental studies indicate that nearly all doves that ingest shot will die as a result of this ingestion. Schulz et al. (2006) estimated that from 8.8 to 15 million doves may be killed each year from ingesting lead shot pellets. If scavengers consume these poisoned doves and secondarily consume the lead pellets, it is estimated that up to an additional one million scavenging birds and mammals could die annually from ingesting poisoned doves alone.

Raptors and other scavenging birds are usually poisoned through ingesting lead shot or bullet fragments in dead or injured prey or gut piles (Friend 1987; Kendall et al. 1996). Common ravens have been shown to have elevated blood lead levels during hunting season due to ingestion of lead in rifle-shot big game offal piles (Hatch 2006; Craighead and Bedrosian 2007, 2008). In Canada, upland game birds and mammals, the primary food source of many raptors, are now more likely to contain lead shot than waterfowl, as lead shot is prohibited for waterfowl hunting (Clark and Scheuhammer 2003).

#### **D. Toxic Effects of Lead on Wildlife**

Lead has long been recognized as a poison to living organisms (Grinnell 1894; Engsted 1932; Horton 1933), with negative effects on general health, reproduction, and behavior (Ris et al. 2004). Lead was highlighted as an important cause of mortality in wildlife populations in the late 1950s, when ingestion of spent hunting lead pellets was recognized to cause death in a wide range of wild waterfowl (Bellrose 1959). Reports of poisoned wildlife have continued frequently since that time (e.g. Bates et al. 1968; Irwin and Karstad 1972; Sanderson and Bellrose 1986; Kramer and Redig 1997; Schulz et al. 2006).

It is well recognized that lead fragments can be absorbed from the gastrointestinal tract of birds and mammals, cause damage in various organs, and result in behavioral changes, significant illness, and even death depending on the amount ingested (Reiser and Temple 1981; Kramer and Redig 1997; Fisher et al. 2006).

Lead fragments or pellets ingested by birds may be rapidly regurgitated (in the pellets of raptors, for example), retained for varying periods, or completely dissolved with the resulting lead salts absorbed into the bloodstream. The likelihood of a bird becoming poisoned is related to the retention time of lead items, frequency and history of exposure to lead, and factors such as nutritional status and environmental stress (Pattee and Pain 2003). A proportion of exposed birds will die, and mortality can occur following the ingestion of just one pellet of lead shot (Pain and Rattner 1988). Ingestion of lead particles usually results in some absorption, and in cases where sufficient lead is absorbed, poisoning ensues. Lead concentrations are generally highest in the blood directly after absorption, and in liver and kidneys for days to months after absorption. Lead deposited in bone can remain for years, and reflects lifetime exposure (Pain 1996). Lead is a non-essential element and the activity of blood enzymes appears to be affected by extremely low concentrations. Other than in cases of point source contamination, high concentrations of lead in the tissues of birds result primarily from the ingestion of lead ammunition or fishing weights.

Various authors have attempted to define tissue concentrations in birds indicative of excessive lead exposure, sub-lethal poisoning and acute poisoning (Franson et al. 1996; Pain 1996), but there is no definitive consensus on “background” lead levels for wild birds. Environmental sources of lead are almost exclusively anthropogenic, with a small contribution from natural sources such as volcanoes. Lead is rarely found in nature in its elemental metal form, and the most common source is galena or PbS, which has a very low solubility in water. Wildlife can get low level exposure to lead from unknown sources, including natural accumulation in plants and ingestion by herbivores, and deposition by leaded gasoline exhaust, now attenuated with regulation. “Baseline” lead concentrations in wildlife can vary between taxa, and the diagnosis of poisoning is usually based on signs of poisoning in combination with blood lead levels in live birds, and on tissue concentrations, sometimes in combination with evidence of exposure to lead in dead birds. For example, the Diagnostic Center for Population and Animal Health (Michigan State University, Lansing MI) defined background blood lead levels as <35 µg/dL for eagles (W. Rumberiha, pers. comm.), while Pattee et al. (1990) defined background levels as <20 µg/dL, and Feierabend and Myers (1984) defined them as <10 µg/dL. Until recently, the generally accepted blood lead levels for wild birds have been <20 µg/dL as background; 20 to <50 µg/dL indicating subclinical poisoning; 50 to 100 µg/dL indicating clinical poisoning; and >100 µg/dL representing severe clinical poisoning (Friend 1985, 1999; Franson 1996; Pain 1996; Pattee and Pain 2003). For condors, blood lead levels above 10 µg/dl, rather than 20 µg/dl, could have detrimental effects on condors and ought to be considered the beginning of toxic exposure (Fry et al. 2009). The background levels of 20ug/dl are now understood to indicate significant exposure, because animals held in captivity usually have background levels of 4 µg/dl or less (Walters et al. 2010).

A threshold toxic level for wildlife is difficult to measure because the effects on the nervous system at low doses can be subtle and difficult to detect without specific quantifiable behaviors. In addition, predisposition and susceptibility to lead can vary between individuals within a species (Pattee et al. 1981, Carpenter et al. 2003). There is probably no toxic lead threshold for any animal, as lead is a neurotoxin with no biological function. Lead salts are rarely encountered in the environment, and animals do not have well established metabolic or detoxification mechanisms to biochemically protect themselves from adverse effects of lead exposure. Even a minor decrease in fitness to a bird surviving in a hostile and competitive environment caused by small amounts of lead ingestion may result in death from other causes. In long-lived bird species, such as condors, eagles and ravens, this has the potential to skew the normal age structure toward younger and non-breeding birds and negatively influence long-term population viability. As the duration of periodic and chronic exposure increases in the condor population so does the likelihood of death by lead-poisoning. It is unknown whether wildlife species sustain sublethal effects on coordination and cognitive behaviors similar to those demonstrated in humans, but it is likely that repetitive sub-lethal exposures to lead will cause permanent neurological and behavioral decrements in all species of wildlife (Canfield et al. 2003; Lanphear et al. 2003; Ris et al. 2004).

Lead is a non-specific poison affecting all body systems. Birds can suffer from both acute and chronic lead poisoning (Bellrose 1959; Redig 1985; Sanderson and Bellrose 1986; Eisler 1988; Scheuhammer and Norris 1996). Birds with acute lead poisoning can appear normal, but experience massive tissue destruction to internal organs and death within a few days (Sanderson and Bellrose 1986). Birds with chronic lead poisoning may develop appetite loss, anemia, anorexia, reproductive or neurological impairment, immune suppression, weakness, and susceptibility to predation and starvation (Grandy et al. 1968; Kimball and Munir 1971; Finley and Deiter 1978; Hohman et al. 1995).

The effects of lead toxicosis in birds commonly include distension of the proventriculus, green watery feces, weight loss, anemia and drooping posture (Hanzlik 1923; Quortrup and Shillinger 1941; Redig et al. 1980; Reiser and Temple 1981; Franson et al. 1983; Custer et al. 1984; Sanderson and Bellrose 1986; Mateo 1998). Sub-lethal toxic effects are exerted on the nervous system, kidneys and circulatory system, resulting in physiological, biochemical and behavioral changes (Scheuhammer 1987). Vitamin metabolism can be affected (Baski and Kenny 1978) and birds can go blind (Pattee et al. 1981). Lead toxicosis depresses the activity of certain blood enzymes, such as delta aminolevulinic acid dehydratase, essential for cellular energy and hemoglobin production, and may impair immune function (Redig et al. 1991; Grasman and Scanlon 1995). Over longer periods, haematocrit and hemoglobin levels are often reduced. Finkelstein et al. (2010) found that sub-lethal concentrations of lead in blood (20 µg/dL), resulted in a 60% decrease in the levels of aminolevulinic acid dehydratase in condors.

As a result of physiological and behavioral changes, birds may become increasingly susceptible to predation, starvation and infection by disease, increasing the probability of death from other causes (Scheuhammer and Norris 1996). Lead can also affect

reproductive success (Cheatum and Benson 1945; Elden 1954; Buerger 1984; Buerger et al. 1986). Grandjean (1976) showed a correlation between thin eggshells and high concentrations of lead in European kestrels (*Falco tinnunculus*). Lead poisoning significantly decreased egg production in captive Japanese quail, *Coturnix japonica* (Edens and Garlich 1983). In ringed turtle doves (*Streptopelia risoria*), significant testicular degeneration has been reported in adults following shot ingestion and seminiferous tubules may be devoid of sperm (Kendall and Scanlon 1981; Veit et al. 1982). Experimental studies on Cooper's hawks (*Accipiter cooperii*) showed detectable amounts of lead in eggs when adults had high levels in their blood (Snyder et al. 1973). In nestlings of altricial species, such as the American kestrel (*Falco sparverius*), body length, brain, liver and kidney weights can be depressed (Hoffman et al. 1985a), along with reduced survival and disrupted brain, liver and kidney function (Hoffman et al. 1985b).

Under some circumstances, there may be sex differences in the probability of exposure to or poisoning by lead, at least in western marsh-harriers (*Circus aeruginosus*), as significantly more females than males trapped had elevated lead concentrations, for unexplained reasons (Pain et al. 1993). Lead exposure may also reduce the likelihood of birds returning to an area to breed (Mateo et al. 1999). Locke and Friend (1992) concluded from their wide-ranging study that all bird species would be susceptible to lead poisoning after ingesting and retaining shot. All raptor species that feed on game could potentially be exposed at some time to lead ingestion, the likelihood varying according to the proportion of game in the diet, the size of game taken, the season, and the local hunting intensity (Pain et al. 1993).

Burger and Gochfeld (2000) found that chronic lead exposure resulted in delayed behavioral response time in both laboratory and wild herring gulls (*Larus argentatus*). Kelly and Kelly (2005) documented moderately elevated blood lead levels increased the risk of collision with overhead power lines for mute swans (*Cygnus olor*). Mallards (*Anas platyrhynchos*) experimentally fed lead exhibited hemolytic anemia during the first week of exposure and neurological impairment during the second week (Mateo et al. 2003). In experimentally fed turkey vultures (*Cathartes aura*) and bald eagles (*Haliaeetus leucocephalus*), lead ingestion decreased weight and muscle mass and caused blindness (Pattee et al. 1981, 2003). Blood pressure increases and renal damage have also been observed in rodents after experimental lead exposure (Victory 1988; Staessen et al. 1994). Bagchi and Preuss (2005) found that acute lead exposure had lasting effects including lowered bone density and increased blood pressure one year after exposure in laboratory rats.

In spite of the abundance of evidence that lead is toxic to wildlife, poisoning rates are not well understood. While massive die-offs are readily visible, daily losses of individual animals are more difficult to detect. This is because sick animals will often isolate themselves, and then are quickly predated upon after death. In one study, observers were given 30 minutes to discover 100 placed carcasses and only found 6 (Stutzenbaker et al. 1983). In another study in which researchers planted carcasses, over 60% of the carcasses

were gone within 3 days and over 90% were gone within 8 days (Humburg et al. 1983; Stutzenbaker et al. 1983).

Sub-lethal lead poisoning may weaken raptors and leave them unable to hunt, or make them more susceptible to mortality from vehicles, power lines, and steel traps (Redig et al. 1980; Fry and Maurer 2003). It has also been suggested that raptors intoxicated with lead may suffer impaired hunting ability and may scavenge to a greater extent or be less selective in their choice of prey (Pain et al. 1993). Sampling methods to determine the exposure to lead intoxication in wildlife have inherent biases as does any wildlife health assessment in the field.

Long-lived species are particularly susceptible to bioaccumulation of lead in bone tissues, and repeated lead ingestion and accumulation in long-lived species can reduce bone mineralization, which could mean an increase in bone fragility (Gangoso et al. 2009). Gangoso et al. (2009) found unusually high level of frequency of fractures and even leg amputations in an Egyptian vulture (*Neophron percnopterus*) population with high exposure to ingestion of lead ammunition.

The non-lethal effects of lead toxicosis may be difficult to recognize at a distance in free-ranging wild animals. Subtle neurological signs are easy to miss even in domesticated animals that can be physically examined. Wild animals that have died from or have been debilitated by lead poisoning may elude capture due to behavioral or physiological changes, or be removed from the population if lead exposure is associated with high levels of mortality (Miller et al. 1998).

Lead poisoning due to ingestion of spent shot or bullet fragments has had population-level effects for some bird species with low recruitment rates, depressed populations, or in recovery, such as the California condor, bald eagle, trumpeter swan, sandhill crane, and spectacled eider (Hennes 1983; Grand et al. 1998; Church et al. 2006).

## **E. Lead Ammunition Poisonings by Species**

Information on lead poisoning of wildlife species in the United States from lead ammunition is detailed below. Information on lead poisoning of wildlife species in Canada and other countries is included in some instances where there is additional research on the effects and prevalence of lead toxicosis for certain species.

### **1. California Condor (*Gymnogyps californianus*)**

The potential effects of lead ammunition in non-waterfowl hunting practices has now received national attention in part because of extensive documentation of harmful levels of lead exposure in the endangered California condor population. Elevated blood lead levels in free-flying California condors have been well described (Locke et al. 1969; Wiemeyer et al. 1986; Janssen et al. 1986; Pattee et al. 1990; Meretsky et al. 2000; Fry and Maurer 2003; Redig et al. 2003; Woods et al. 2006; Hunt et al. 2006; Sullivan et al. 2006; Parish et al. 2006; Church et al. 2006). Wild condors in California are captured

once or twice per year, and blood samples are taken as part of an extensive lead monitoring program for the reintroduced population. Condors with concentrations below 20 µg/dl in blood are considered to have only background exposure, concentrations between 20–59 µg/dl indicate elevated exposure to lead, concentrations between 60–99 µg/dl suggest birds may be clinically affected, and levels above 100 µg/dl indicate acute toxicity (Redig et al. 1983). Fry and Maurer (2003) and Fry et al. (2009) reported that since blood monitoring was implemented in California in 1997, 83% of all free-flying condors tested have had detectable exposure to lead. A review of medical records from captive condors at the San Diego Wild Animal Park was conducted to identify blood lead reference ranges for condors not exposed to lead sources in the wild (Dujowich et al. 2005). Among 95 captive born condors tested, all had blood lead levels below detection limits of 6 µg/dl with one exception testing at 11.0 µg/dl (Dujowich et al. 2005).

For condors released in southern California (Ventura, Santa Barbara and San Luis Obispo counties), blood lead concentrations were evaluated in 214 samples from 44 individuals (Hall et al. 2007). Forty-four percent (95/214) of these blood samples obtained during captures from 1997 to 2004 had lead concentrations consistent with elevated levels of exposure (>20 µg/dl), with 8% (18/214) at clinically significant concentrations and 3% (7/214) at acutely toxic concentrations (Hall et al. 2007). Seventy seven percent of the individual condors tested (34/44) showed elevated exposure; 32% of condors (14/44) had concentrations considered to be clinically significant, and 14% (6/44) had concentrations consistent with acute toxicity in at least one of their samples. Half of the individuals had elevated levels in multiple samples suggesting repeated exposure events (Hall et al. 2007). Subadults (age 4-5 years) in this cohort had higher exposure than adults classified as 6 years and older (Hall et al. 2007). Condors were found to have increased blood lead concentrations the second year after release reaching a peak 4 years post-release and then generally declining (Hall et al. 2007). Highest lead concentrations coincide with the age class most likely to forage widely, but detailed comparisons of condor movements and lead concentrations have not been done on a large scale for the California population.

The nearly three dozen condors released in Big Sur, California were repeatedly sampled over a decade to produce a total of 126 independent measurements of blood lead concentration. This group reports 21% (27/126) of samples to be above background levels, with only 3% (4/126) of samples at clinically significant levels and only 2% (2/126) indicative of acute toxicity (Sorenson and Burnett 2007). Condor lead concentrations were significantly higher in year 6 and year 8 post-release (Sorenson and Burnett 2007). Most of the birds released at Big Sur (21/33) visited southern California at some point, and for those that did so, they did this on average 2 years post release (Sorenson and Burnett 2007). The authors attributed the lower prevalence of lead exposure in Big Sur condors than in southern California condors to their finding that out of 26 observed feeding events on wild prey, 20 were California sea lions in contrast to only 3 observations of condors feeding on deer, which were far more likely to be hunter-shot (Sorenson and Burnett 2007).

Pettersson et al. (2009) collected 63 blood samples from 20 condors at Pinnacles National Monument from 2003 to 2007 and compared blood lead values before and after release.

Of 63 post-release samples, 24 (38%) were above background (20–59 µg/dL), two (3.2%) were clinically affected (60–99 µg/dL), and two more (3.2%) were indicative of acute toxicity ( $\geq 100$  µg/dL). Fifteen (75%) of individuals sampled were exposed at least once and eight (40%) were exposed on two or more occasions. Petterson et al. (2009) found a significant difference comparing samples collected before release and within one year after release from the same individuals, revealing that even young, inexperienced condors in this area are vulnerable to lead exposure.

As of 2011, nearly half of the roughly 130 condors released since 1996 along the Arizona-Utah border have died or vanished, with lead poisoning being the leading cause of death.

A recount on lead intoxication events of wild and captive-reared condors in California and Arizona from 1992 to 2002 was compiled by Fry (2003) with information from the Condor Recovery Program. Condors with greater than 40 µg/dl lead in blood measured with a portable lead analyzer in the field were brought into captivity for chelation treatment to reduce blood lead concentrations. Among condors released in southern California, at least 8 had been brought back into captivity and received emergency chelation therapy as of 2007 (Hall et al. 2007). Four of these birds had lead levels exceeding 180 µg/dl and were likely to have died or been severely debilitated without emergency intervention (Hall et al. 2007).

Free-flying condors are also captured once or twice per year in Arizona to measure lead exposure. Out of a total of 437 samples, 31% (137/437) had elevated lead concentrations (15-59 µg/dl), and 9% (39/437) exceeded 60µg/dl (Parish et al. 2006). Chelation therapy was administered 66 times to a total of 28 individuals from 1996 to 2005 in Arizona (Parish et al. 2006).

In addition to capture and treatment of condors found with high lead levels, management practices in both California and Arizona include supplemental feeding to reduce lead exposure. Several reports suggest that the condor mortality due to lead would be much higher if the free-flying population were not intensively managed by supplemental feeding and chelation treatment to minimize the impact of lead exposure events (Fry and Maurer 2003; Woods et al. 2006; Pattee et al. 2006; Hall et al. 2007; Mee and Snyder 2007).

Causes of condor mortality were reviewed in detail for 41 free flying condors that died in California and Arizona between 1992 and 2002 (Fry and Maurer 2003). Of the 41 condor carcasses found and examined, lead toxicity was documented as the cause of death in 12% (5/41) (Meretsky et al. 2000; Fry and Maurer 2003). Predation (22%; 9/41) and power line electrocutions and collisions (20%; 8/41) were identified as the leading causes of reintroduced condor mortality in California and Arizona during this time frame (Fry and Maurer 2003). While power line collisions and electrocutions were particularly problematic for the early condor releases in California, mortality due to this cause has been reduced substantially in recent years since power line aversion training was instituted as part of the reintroduction program (Mee and Snyder 2007). The coarse

terrain and wide-ranging movements of the condor make it difficult to find deceased animals within a timeframe that allows for the accurate determination of causes of death. Unless carcasses are recovered in fresh post-mortem condition, it can be exceedingly difficult to identify causes of death that are only recognizable by microscopic examination of tissues or laboratory analyses of samples. It can also be difficult to distinguish whether or not disease or intoxications have altered an individual's behavior and initiated a chain of events leading to trauma or some other cause of death. The exceedingly high blood lead levels reported in some free-flying condors suggest that these birds may have compromised abilities to avoid hazards. Therefore, cause of death could not be accurately determined for 20% (8/41) of recovered condor carcasses. An additional 11 condors were lost to follow up during this time period. While likely dead, these condors were never recovered.

A more recent review of the 66 condors released in southern California found that among the 34 condors that died in this area from 1992-2005, exact cause of death could be determined for 18 birds (Hall et al. 2007). Lead toxicity is believed to be the primary cause of death in 3 of these birds (17%). Ages at death for the three condors with lead poisoning were 1.7, 2.5 and 4.8 years. Condor deaths due to lead toxicity have not been reported for the 33 condors released in Big Sur, California (Sorenson and Burnett 2007). Out of a total of 26 condor deaths observed in Arizona between 1996 and 2005, at least 6 and perhaps as many as 8 (23-31%) died from lead poisoning (Woods et al. 2006; Parish et al. 2006). Mainly because of a marked recent increase in the number of lead-related mortalities in condors released in Arizona, lead poisoning is now the leading known cause of death in free-flying condors. Data presented in these reports do not include the deaths of additional released condors in California and Arizona that have died due to lead poisoning from lead ammunition since 2007 (Peregrine Fund 2010; VWS 2010). At least three dozen condors in California and Arizona have now died from lead exposure from ingestion of lead ammunition fragments or lead shot, with many, many more deaths suspected to involve lead poisoning.

Chronic and frequent sub-lethal lead exposure for condors has been well-documented. A disturbing number of the released condors must undergo frequent chelation therapy to save their lives from lead poisoning due to continual exposure to lead. In 2006 alone, 95% of all Arizona condors had lead exposure and 70% of the Arizona population had to receive life-saving chelation treatment. In 2007 alone there were 50 cases of lead exposure in Arizona condors. In 2008 and 2009, the Peregrine Fund reported having to treat "a large portion" of the wild Arizona condor population with chelation therapy for increased lead levels during the winter of 2008 and a "significant amount" of lead exposure to condors in the winter of 2009 (Peregrine Fund 2010). In June of 2008, 7 condors fell ill from lead poisoning in just one feeding event on Tejon Ranch, the highest lead exposure event in Southern California in 10 years. In 2008 the blood lead levels of 72 free-flying condors in California were tested; from January to June, 59 percent of the condors sampled had blood lead levels that were considered above background (>10 micrograms/deciliter) levels; 45 percent of condors exhibited blood lead levels above background levels during July-December 2008 (CFGC 2009).



Lead poisoning has begun to interfere with the first breeding of released condors in the wild; one of the lead poisoning deaths in California in 2008 was a parent with a chick in the nest; in 2009 a breeding condor died of lead poisoning; and in December 2008 the first condor female to successfully hatch, and fledge, a wild-produced condor in Arizona in close to a century died of lead poisoning, as did her wild-produced offspring. In early 2010, the first California condor chick to hatch inside a national park in more than a century was severely lead poisoned, likely from eating carrion contaminated with fragments of lead bullets. The condor chick and its male parent had to be taken from the nest at Pinnacles National Monument for treatment and the chick could suffer lasting neurological damage as a result.

If lead exposure is not high enough to cause acute intoxication and death or to impair survival skills, lead should be eliminated from condors gradually through natural processes. Fry and Maurer (2003) calculated an average depuration rate (or half-time for lead elimination from blood) of about 11-15 days. This finding, along with the high proportion of samples with elevated blood levels (see Fry et al. 2009), suggest that condors are frequently and repeatedly exposed to lead in the wild. The clinical consequences of recurrent lead poisoning are uncertain, but will likely result in long-term neurological injury (Fry et al. 2009). Fry et al. (2009) analyzed 469 blood samples taken from 95 different condors in California since 2000, and found that 79 of these condors (83%) have had at least one significant lead exposure incident, and some condors have been lead poisoned multiple times (up to 13 times for one bird). There were 276 separate documented incidents of blood lead levels in excess of 10  $\mu\text{g}/\text{dL}$ ; and 27 poisonings in excess of 50  $\mu\text{g}/\text{dL}$  that required emergency clinical care to prevent permanent injury or death. Similar observations of high lead levels in blood and tissues of sympatric species, such as vultures, eagles, hawks and ravens in the condor range support the conclusion that environmental lead is widely available to scavenging birds (Wiemeyer et al. 1988; Pattee et al. 1990).

Many studies have attributed lead exposure in condors to lead bullet fragment ingestion when eating hunted animal carcasses (Locke et al. 1969; Janssen et al. 1986; Meretsky et al. 2000; Fry and Maurer 2003; Hunt et al. 2006; Woods et al. 2006; Church et al. 2006). Lead from environmental sources, such as air and water pollution, may accumulate in animals, but environmental exposure is not likely to result in levels high enough to cause mortality (Pattee et al. 1990). The very high level of lead detected in most individuals of the free-flying condor population is consistent with a highly concentrated source of exposure not typically found in air, water or soil unless in an area contaminated from lead mining and smelting activities.

Condors are exclusively carrion feeders, and the condor diet includes deer, sea lions, whales, squirrels, rabbits, skunks, coyotes, pigs and cattle. The relative proportion of these various components in condor diet is very hard to assess given the difficulties involved in directly observing condor feeding behavior in the wild. Observed condor feeding behavior in southern California, although sporadic, has most commonly involved deer and cow or calf carcasses (Hopper Mountain NWR unpublished data). Intensive monitoring of the condors released in Arizona has resulted in the documentation of

condors feeding on 78 deer, 42 elk, 10 coyotes, 51 domestic livestock and 16 miscellaneous animals (Hunt et al. 2007). Condors released in Big Sur are the only population with a diet that includes marine mammals. Out of 26 feeding observations made on condors released in Big Sur, 77% involved sea lion carcasses and only 15% involved deer and elk carcasses (Sorenson and Burnett 2007). In 1984, Wiemeyer et al. evaluated environmental contaminants including biologically incorporated lead in condor prey species, testing muscle, fat and placenta from cattle, sheep and mule deer (*Odocoileus hemionus*). Lead levels in these potential food items were low in all but one muscle sample from the head of a hunter killed deer (17.5 parts per million, ppm) and one cattle placenta sample (1.82 ppm; Wiemeyer et al. 1984).

Deer killed by hunters, predation, vehicular collisions, fire and disease are potential food sources for condors. Condors have been directly observed feeding on deer killed by hunters, and there are several observations of multiple condors feeding on deer offal piles in California (Hopper Mountain NWR unpublished data) and Arizona (Hunt et al. 2007). In the Kaibab Plateau in Arizona 15 of the 55 deer carcasses involved in condor foraging events were hunter-killed (Hunt et al. 2007). Animal carcasses that have been shot with lead ammunition are likely to contain fragments of lead even if the bullet passed through the carcass or if the primary shot fragment has been removed (Hunt et al. 2006). Offal piles left in the field are also very likely to contain lead fragments, since these piles usually contain thoracic organs and hunters often aim for the thorax when targeting large mammals (Hunt et al. 2006).

Inter-annual variation and seasonal trends in lead exposure have been observed in all condor populations. The 44 condors released in southern California showed substantial inter-annual variation in blood lead concentrations with samples from 2001-2004 having a significantly lower mean than samples from 1997-2000 (Hall et al. 2007). This temporal trend has been explained by a move in release, food provisioning and trapping (sampling) location from the Sierra Madre Mountains to Hopper Mountain NWR in 2001. Condors trapped at the Sierra Madre site had a significantly higher mean lead concentration than condors trapped at Hopper Mountain. The Sierra Madre site is characterized by greater public access and hunting activity than the Hopper Mountain site (Hall et al. 2007). Increases in blood lead levels in condors tested during the deer hunting season have also been reported by Hall et al (2007), but sampling effort was not distributed evenly in all seasons. In fact, sampling between January and May was very limited (with only 20/214 samples in these months). This study noted that while mean lead concentration was significantly higher in condors sampled during deer hunting season, elevated lead exposure was detected at other times of the year with 38% (20/53) of blood samples collected in June having lead concentrations exceeding 20 µg/dl. Blood samples in the 33 condors at Big Sur also showed inter-annual and seasonal variation in lead concentration with samples obtained in 2005 and samples obtained in September and October showing the highest mean concentration of lead (Sorenson and Burnett 2007). This peak in lead concentrations in the Big Sur condor population does correspond with the time period in which hunter-shot deer are most prevalent in the coast range (Fry and Maurer 2003).

The studies conducted on the introduced condor population in Arizona by Hunt et al. (2006) show correlations between increased lead exposure and foraging in deer hunting areas during and just following the hunting season. Spikes in blood lead levels of condors during November and December correspond with the deer hunting seasons and condor movement to deer hunting areas (Parish et al. 2009). Since condors began foraging in the Kaibab Plateau in 2002, detected lead exposures have been temporally and spatially clustered and highly predictable (Hunt et al. 2007). Blood lead levels in condors visiting the Kaibab Plateau were significantly higher than condors not visiting this intensively hunted area, and evidence of lead intoxication in live and dead condors peaked annually in November and December from 2002 to 2004, coincident with the deer hunting season (Hunt et al. 2007). Increased proficiency of condors at finding carrion in the wild corresponds with a greater incidence of lead exposure, and information collected on food types supports the hypothesis that lead ammunition residues in rifle- and shotgun-killed animals are the principle source of lead contamination among condors in northern Arizona and southern Utah (Parish et al. 2009). Chesley et al. (2009) evaluated lead isotopic ratios from blood samples of 47 condors in Arizona over 3 years and collected 12 metal fragments from 6 birds with elevated blood lead levels, directly linking ingested lead ammunition fragments to lead in the blood of Arizona condors. Lead poisoning has been the leading cause of death among reintroduced condors in Arizona from 1996 to 2007 (Parish et al. 2009).

Condor lead intoxications reported in both California and Arizona during non-deer hunting seasons suggest that deer hunting practices are not the only potential source of lead for condors. Firearms are used in the California condor range year-round for taking non-game animals, such as ground squirrels and coyotes, which are typically left in the field and available for scavenging species (Pattee et al. 1990). Rabbits, squirrels, coyotes, and pigs shot with lead ammunition likely pose a similar risk for exposure as do hunter-killed deer carcasses, and these animals are more likely to be left in the field if they are not a food source or trophy for hunters. Condors have been observed feeding on hunted pigs at private dumps and piles of dead ground squirrels shot for pest control (Johnson et al. 2007). Two rifle-killed coyotes were observed as a food source for condors in Arizona, and hunted coyotes have been suggested as a potential source for summer lead exposure in condors (Parish et al. 2006; Hunt et al. 2007).

Direct evidence of consumption of ammunition by condors is extremely difficult to obtain given the lag time between likely ingestion/exposure and debilitation or death. In addition, ingested lead fragments can pass through the digestive tract or be completely digested and absorbed if very small. Radiographs are unlikely to detect radio-opaque particles less than 1 mm in diameter, and similarly sized particles may be easily missed at surgery or necropsy. Nonetheless, physical evidence of ammunition inside the stomachs of individual condors that have died or have been diagnosed with high blood lead levels, have occurred in 14 cases in Arizona (Parrish et al. 2006). Of these 14 condors, 7 (3 alive, 4 dead) had shotgun pellets and 7 (6 alive, 1 dead) had spent rifle bullets in their digestive tracts either on radiographs or during necropsy (Parish et al. 2006). In California, from 1984 to 2002, 7 condors had metal detected in their gastro-intestinal

tracts, but identification of fragments and analysis of samples for lead content were not performed (Fry and Maurer 2003).

Ammunition was implicated as the main source of lead exposure in released condors in recent studies by Church et al. (2006) and Chesley et al. (2009). The Church et al. (2006) study compared lead isotopic ( $^{207}\text{Pb}/^{206}\text{Pb}$ ) ratios in blood samples from released free-flying condors in Central California and prerelease condors in Southern California; tissue samples from possible condor diet items (calves, road-killed deer and a sea lion); and samples from ammunition sold for bird and mammal hunting at stores within the condor range. The lead isotope ratios in free-flying condors differed significantly from those in captive pre-release condors providing further evidence that the sources of exposure for free-flying condors were different from the sources causing background levels of exposure in captive condors. Furthermore, the low background concentrations of lead detected in non-hunter killed condor diet samples had isotopic ratios similar to those described for environmental lead in rivers, lakes, atmospheric dust and urban aerosols. These findings provided evidence that “environmental” sources of lead, such as background levels in water, soil and non-hunter killed carcasses, were not responsible for the elevated lead exposures observed in free-flying condors in California. The lead isotopic ratios in the elevated free-flying condor samples were similar to those found in the ammunition samples tested (Church et al. 2007).

The lead isotope ratio technique has been also recently applied as a forensics tool to trace lead sources involved in condor deaths. A feather from one condor (#165) released in Arizona and found dead nearly 3 years later (June 2000) from acute lead poisoning with 16-17 shotgun pellets in its stomach was analyzed for lead concentration and lead isotope composition (Church et al. 2006). The lead isotopic ratio in the feather from this condor (in the area of the rachis and vane with most recent growth) closely matched that detected in ammunition samples from stores in California (Church et al. 2006). Further analysis of concentrations of total lead in the bones of three other dead condors (#132, 175 and 181) strongly suggest that lead poisoning or debilitation induced by lead contributed to their deaths, but the isotopic ratio in tissues from condors #175 and # 181 were unlike those of the ammunition samples tested to date. However, the isotope ratio in tissues from condor #132 closely matched that of the ammunition samples tested in the study by Church et al (2006).

Finkelstein et al. (2010) compared blood and feather lead isotopic composition in lead-poisoned condors to spent ammunition from a recovered pig carcass fed upon by the birds to provide irrefutable evidence for exposure to lead-based ammunition. Finkelstein et al. (2010) also analyzed lead isotope ratios in 65 released California condors and demonstrated that lead in the condors (isotope ratio values of between 0.81 and 0.83) is within the range of that found in bullet samples, most of which were turned in by hunters in California. Pre-release birds had lower concentrations of lead in their blood, and their isotopic ratios were higher (0.83 to 0.85). Parmentier et al. (2009) showed that the lead concentration and isotopic composition of condor feathers examined changed following a documented ammunition-exposure event, arriving at values that matched exactly the isotopic composition of recovered ammunition. Finkelstein et al. (2011) further analyzed

lead isotopes in blood samples from pre-release and free-flying condors in California and compared them with a representative selection of 71 different lead-based ammunition samples, most collected in the field. The lead isotopic signature in free-flying condors, which can scavenge on carcasses tainted with lead ammunition fragments, differs from that in pre-release birds. About 90 percent of blood samples from free-flying condors had an isotopic composition best explained by exposure to lead-based ammunition.

Further lead isotopic analyses of ammunition and other potential point sources in the condor's habitat, along with bones, feathers and blood of other condors have developed a more conclusive association between ammunition-derived lead intoxications and condor mortalities. Feathers are a particularly instructive forensic tool to reconstruct lead poisoning in California condors. Finkelstein et al. (2010) used sequential feather sampling and analysis to show that feather lead concentrations can help estimate annual lead exposure risk and give better long-term monitoring of lead exposure. Sampling two or more growing primary feathers over a year will provide a time series of lead exposure and capture 60% of a bird's annual lead exposure history, compared to only 10% of an annual exposure history reflected in one or two blood samples collected over the same time period.

Parmentier et al. (2009) demonstrated from evaluating lead concentration and stable isotopic measurements in growing condor feathers that lead-exposed condors are suffering sub-clinical toxicity, based on  $\delta$ -aminolevulinic acid dehydratase ("ALAD") inhibition by lead. Preliminary results of nine condors with blood lead concentrations ranging between 1.9-64.0  $\mu\text{g/dL}$  show a significant inverse relationship between blood lead concentration and ALAD activity, indicating significant inhibition of ALAD at blood lead levels below those where clinical chelation treatment is indicated. Church et al. (2009) showed increases in phosphorus and enzymes in condors with high blood lead levels that may be indicative of lead-induced nerve tissue damage or renal disease and kidney dysfunction. Finkelstein et al. (2011) demonstrated that lead ammunition exposure causes chronic, long-term health effects in condors as well as acute poisonings. Nearly all 100 free-flying condors in California have suffered from severe lead poisoning at least once, and 35 percent of condor blood samples from 2004 to 2009 showed high blood lead levels indicating chronic exposure to potentially lethal lead levels (Finkelstein et al. 2011).

The population-level impact of condor exposure to lead may be difficult to quantify but is clearly significant. For small populations in particular, increased adult bird mortality at any measurable rate is likely to affect population dynamics (Westemeier et al. 1998; Fisher et al. 2006). Re-introduced condor populations are currently being intensively managed to reduce lead exposure, and the proportionate mortality due to lead exposure would almost certainly be higher if individual animal interventions ceased. While intensive management has been an important component of condor recovery efforts to date, its practicality in the long term is questionable as the condor population grows in size. More importantly, such close monitoring and frequent recapturing are counterproductive to the establishment of a behaviorally normal self-sustaining wild condor population (Condor Recovery Team, Lead Exposure Reduction Steering

Committee, 2003). In order to ensure the recovery of the California condor, lead ammunition must cease being one of the species' greatest threats.

## 2. **Bald Eagle (*Haliaeetus leucocephala*) and Golden Eagle (*Aquila chrysaetos*)**

Bald eagles share some demographic and ecological factors with free-ranging condors that make them vulnerable to lead intoxication; they scavenge on carcasses, they are long-lived, they have low recruitment rates, and their numbers have been reduced in recent decades (Pattee et al. 1990). Bald eagles that ingest lead shot embedded in the tissues or the intestinal tract of waterfowl demonstrate acute and chronic symptoms of lead poisoning (Hoffman et al. 1981; Miller et al. 2001). The experimental intoxication of bald eagles with lead shot conducted by Pattee et al. (1981) found that it took between 10 and 133 days (median 20 days) for mortality to occur. The range of time for lead shot retention in the stomach varied between 0.5 and 48 days. Mean lead levels in dead animals were 16.6 ppm (wet weight) in liver and 6.0 ppm (wet weight) in kidney (Pattee et al. 1981). In a complementary study, Hoffmann et al. (1981) report mean blood lead levels in eagles dosed with 10 #4 lead shot (0.21g each) to be 80 µg/dl after 24 hours and 280 µg/dl after 72 hours. Mean blood lead levels as high as 270 µg/dl have been detected in apparently healthy free-ranging bald eagles but subclinical effects may be difficult to document (Reiser and Temple 1981). Foreign bodies, including lead fragments, may be regurgitated by eagles so that fragments may not be detected in the gastrointestinal tract at the time of capture or blood tests, even if the fragments contributed substantially to elevated lead exposure levels prior to being ejected. Mateo et al. (2003) recognized the importance of accounting for this unique physiology in raptors and recommend collecting regurgitated pellets at raptor roosting sites to study the presence, frequency, seasonality and prey associated with the ingestion of lead shot.

The secondary poisoning of bald eagles by lead shot in crippled waterfowl was part of the impetus for the final decision to ban the use of lead for hunting waterfowl (Kendall et al. 1996; Kramer et al. 1997). Coon et al. (1969) reported that 7% of 45 bald eagle carcasses had high enough lead levels to be lethal. Kaiser et al. (1990) reported 9% of 158 bald eagle carcasses had elevated lead levels in the liver. In one study, 97% of bald eagles and 86% of golden eagles tested had elevated blood levels of lead (Harmata and Restani 1995).

Pattee and Hennes (1983) found that elevated lead levels in bald eagles corresponded well (89%) with late fall and winter waterfowl hunting seasons. However, a study attempting to trace lead poisoning in bald eagles to diet preference did not find significant differences in blood lead levels among eagles feeding on fish and eagles feeding on waterfowl in an area where waterfowl hunting was intensive (Miller et al. 1998). According to the Wisconsin Department of Natural Resources, about 15 to 20 percent of all bald eagle deaths in that state are due to lead poisoning (Eisele 2008; Strom et al. 2009), usually from eating animals that were wounded with lead ammunition or from scavenging gut piles during and after the deer hunting season. Wisconsin lead poisoning cases in bald eagles begin to increase in October, peak in December and tail off in late

winter, which coincides exactly with Wisconsin's deer hunting seasons, suggesting hunter-crippled game and lead contaminated offal are the cause.

A 16 year review of lead levels in bald and golden eagles in Minnesota and Wisconsin by Kramer and Redig (1997) found that observed blood lead concentrations in both species declined following the ban on lead shot in waterfowl hunting, but there was no change in the prevalence of lead poisoning, attributable in part to continued availability of gut piles from hunter-killed deer. In that study, 21% (138/654) of eagles admitted to treatment centers had evidence of lead poisoning, and only one had radiographic evidence of lead fragments in the gastro-intestinal tract (Kramer and Redig 1997). Other potential sources of lead, such as fish contaminated with lead fishing sinkers, and hunting activities not included in the lead shot ban were suggested as causes for the substantial number of cases reported during this time period. Clark and Scheuhammer (2003b) found, not surprisingly, that upland game birds and mammals, the primary foods for many raptors, were more likely to contain lead shot than waterfowl 12 years after the ban on lead shot for waterfowl hunting. Lead shot from upland game hunting and lead bullet fragments from big game hunting and “varmint” shooting are a significant cause of continued lead toxicity for bald and golden eagles (Harmata and Restani 1995; Fisher et al. 2006; Hunt et al. 2006; Pauli and Buskirk 2007).

Golden eagles share some feeding ecology and behaviors with California condors and bald eagles and therefore may be exposed to some of the same factors that predispose condors to lead intoxication. In the study by Pattee et al. (1990) on the lead hazards within the California condor range, golden eagles were suggested as a model species to assess lead exposure in California condors because they are abundant in the condor range and they have been observed feeding on the same carcasses as condors. Between 1985 and 1986, 36% of the 162 golden eagles evaluated within the California condor range had elevated blood lead levels, and 2.5% had levels greater than 100ug/dl, indicative of clinical lead poisoning. This study also reported seasonal trends in lead levels in tissues of golden eagles within the California condor range which coincided with the deer hunting season (Pattee et al. 1990).

Wildlife rehabilitators in Iowa began gathering lead poisoning information on bald eagles in 2004, analyzing blood, liver, or bone samples for 62 eagles (Neumann 2009). Thirty-nine eagles showed lead levels in their blood above 0.2 ppm or lead levels in their liver above 6 ppm, which could be lethal poisoning without chelation treatment. Seven eagles showed exposure levels of lead (between 0.1 ppm and 0.2 ppm in blood samples, between 1 ppm and 6 ppm in liver samples, and between 10 ppm and 20 ppm in bone). Several of the eagles admitted with traumatic injuries showed underlying lead exposure or poisoning. Over half of the eagles being admitted to Iowa wildlife rehabilitators have ingested lead. Behavioral observations, time-of-year data analysis, and x-ray information point to lead shrapnel left in slug-shot white-tailed deer (*Odocoileus virginianus*) carcasses to be a source of this ingested lead (Neumann 2009). Thousands of bald eagles winter in Iowa, up to one fifth of the lower 48 states population.

The Washington Department of Fish and Wildlife conducted a four-year study of golden eagles in Washington that showed increased lead levels in golden eagles.

Spring migrating eagles sampled in west-central Montana between 1983 and 1985 showed elevated blood-lead levels in 85% of 86 golden eagles and 97% of 37 bald eagles, with the source thought to be shot from waterfowl hunting and fragmented lead-core rifle bullets in ground squirrels (Harmata and Restani 1995). Domenech and Langner (2009) sampled blood from 42 golden eagles in Montana captured on migration during the fall of 2006 and 2007 and found that 58% had elevated blood-lead levels, attributed to ingestion of lead-tainted carcasses or offal piles. Of the eagles evaluated by Domenech and Langner (2009), 18 contained background lead levels of 0–10 µg/dL, 19 eagles were considered sub-clinically exposed at 10–60 µg/dL, two birds were clinically exposed (60–100 µg/dL), and three exhibited acute exposure of >100 µg/dL. Eagles with lower, but detectable blood lead levels may have had earlier exposure with the majority of the lead already deposited in other organs and bone.

Bedrosian and Craighead (2009) measured blood lead levels of 47 bald eagles and 16 golden eagles in the southern Yellowstone Ecosystem around Grand Teton National Park, Wyoming during and after large-game hunts for two years. They found a median blood lead level of 41.0 µg/dL (range = 3.2–523 µg/dL); 75% of all birds tested exhibited elevated lead levels (>20 µg/dL) and 14.3% exhibited levels associated with clinical poisoning (>100 µg/dL). The median blood lead levels for eagles during the hunting season was significantly higher than the non-hunting season (56.0 vs. 27.7 µg/dL, respectively;  $P = 0.01$ ). The magnitude of lead in the blood of Wyoming eagles is extremely high and likely results in the death of some individuals (Bedrosian and Craighead 2009).

Studies of eagle species in other countries confirms high levels of lead poisoning and lead poisoning from eagles scavenging carcasses tainted with lead ammunition as a significant cause of death. Lead poisoning is a significant cause of death for golden eagles and some other upland-foraging raptors in Canada that may feed on dead or wounded upland prey with embedded lead shot or bullet fragments (Scheuhammer 2009). Kurosawa (2000) first reported lead poisoning in sea eagles in Japan, and Saito (2009) reported on 129 mortalities of Steller's sea-eagles (*Haliaeetus pelagicus*) and white-tailed eagles (*Haliaeetus albicilla*) on the island of Hokkaido, Japan from 1996 to 2007 diagnosed as lead poisoning fatalities. Necropsies and radiographs revealed lead fragments from rifle bullets and from shotgun slugs in the digestive tracts of poisoned eagles, providing evidence that a source of lead was spent ammunition from lead-contaminated Sika deer carcasses, which are a major food source for wintering eagles. Post mortem examinations of more than 390 white-tailed sea eagles (*Haliaeetus albicilla*) in Germany, an umbrella species for other scavenging birds, have shown that lead poisoning is the most significant cause (23% of mortality) of death (Krone et al. 2009). Krone (2004) also reported lead poisoning of seal eagles in Greenland. Potential sources of lead were waterfowl such as geese and carcasses of game animals or their remains (gut piles) shot with lead-containing bullets. Captured geese and shot game animals examined by radiograph revealed embedded lead shot pellets and large numbers of lead particles.



### 3. Turkey Vulture (*Cathartes aura*)

While mortality due to lead exposure in turkey vultures is not well documented, dead turkey vultures sampled within the condor range have been documented as having elevated lead exposure (Weimeyer et al. 1988). Experimental lead intoxication studies in turkey vultures suggest that vultures can succumb to lead poisoning, although studies have demonstrated that turkey vultures are able to tolerate very highly elevated lead concentrations in blood. One experimental intoxication study, conducted by Carpenter et al. (2003), administered turkey vultures daily oral doses of one, three or ten BB-sized lead shot (0.35 to 0.45 grams) over a six month observation period. While most measured parameters were similar to those reported for other avian species, survival time (143 to 211 days), even at the higher level of exposure, was much longer than reported for other species, suggesting turkey vultures may be less sensitive to the deleterious effects of lead ingestion (Carpenter et al. 2003). In a separate experimental trial by Reiser and Temple (1981), one turkey vulture was more susceptible to lead intoxication than two red-tailed hawks (it is difficult to generalize to the species level and rule out individual responses with this sample size).

Kelly and Johnson (2011) found that blood lead levels in free-flying turkey vultures rose during deer hunting season and in areas with wild pig hunts. Kelly and Johnson (2011) compared blood lead concentration in turkey vultures within and outside of the deer hunting season, and in areas with varying wild pig hunting intensity. Lead exposure in turkey vultures was significantly higher during the deer hunting season compared to the off-season, and blood lead concentration was positively correlated with increasing wild pig hunting intensity. Their results link lead exposure in turkey vultures to deer and wild pig hunting activity.

Additional reports on individual cases of lead toxicosis in turkey vultures have been published. Clark and Scheuhammer (2002) evaluated 184 raptors (16 different species) in Canada and the highest bone lead concentration was found in a turkey vulture, suggesting this bird was likely exposed to a series of sublethal doses of lead in carrion. Platt et al. (1999) observed histopathological peripheral neuropathy in a turkey vulture with toxic blood lead concentrations.

### 4. Other Raptors

Lethal effects from ingestion of lead shot by predatory and scavenging raptors feeding on hunter-killed carcasses have been documented in red-tailed hawks (*Buteo jamaicensis*), northern goshawks (*Accipiter gentilis*), and great horned owls (*Bubo virginianus*).

### 5. Waterfowl

In North America, ducks and geese for years suffered significant losses from lead poisoning by ingesting spent lead shot on the bottom of ponds and marshes. Grinnell (1894) first reviewed lead poisoning in waterfowl and others documented poisonings

shortly thereafter (Bowles 1908; McAtee 1908; Wetmore 1919; Munro 1925). It was estimated that from 1.6 to 3.9 million waterfowl died each year in North America from lead poisoning before the national ban on lead shot for waterfowl hunting in 1991 (Bellrose 1959; Feierabend 1983). Lead poisoning from spent lead shot caused an estimated 2 to 3 percent of the annual losses of North American waterfowl between 1938 and 1954 (Bellrose 1959). In Washington, prior to the ban on waterfowl hunting with lead shot, biologists reported that 4.1-4.5% of harvested waterfowl contained ingested lead shot in their digestive tracts (Jeffrey 1977; Driver and Kendall 1984), however the extent of lead poisoning in the entire Washington waterfowl population was unknown. Within six years of the ban, there was an estimated 64% decline in ingestion of lead shot by waterfowl on the Mississippi flyway (Anderson et al. 2000). Of examined ducks whose gizzards contained ingested pellets, 68% of mallards, 45% of ring-necked ducks, 44% of scaup, and 71% of canvasbacks contained only non-lead shot (Anderson et al. 2000). Samuel and Bowers (2000) demonstrated a 44% reduction in lead exposure (defined as >0.2 ppm in blood) of black ducks in Tennessee comparing exposure from 1986-1988 with the post-lead shot ban from 1997-1999. Similar decreases in mean bone lead concentrations in hatch-year ducklings were shown in Canada after implementation of lead shot bans (Stevenson et al. 2005). After non-lead shot regulations for most migratory game birds were established and implemented nationwide from 1990 to 1999 in Canada, the incidence of elevated lead exposure in hatch year ducks declined dramatically, testifying to the effectiveness of the regulations and a generally high compliance by hunters (Scheuhammer 2009).

The effects of ingested lead shot on waterfowl have been well documented (Bellrose 1959; Dieter and Finley 1978; Roscoe et al. 1979; Sanderson and Bellrose 1986; Pain and Rattner 1988; Rattner et al. 1989; Pain 1996; Franson et al. 1996; Friend 1999; Pattee and Pain 2003). As few as one or two ingested lead shot pellets can cause waterfowl to waste away and die over a period of several weeks. Ducks debilitated by lead may be more vulnerable to hunting and may have impaired migratory behavior (Bellrose 1951). Lead shot ingestion rates for waterfowl are related to density of spent shot (Rocke et al. 1997).

### *Swans*

Swan lead fatalities from ingestion of spent lead shot have been occurring since at least 1925 (Munro 1925). Some of the most dramatic examples of mass mortality of waterfowl due to ingestion of lead shot involve the deaths of thousands of wintering trumpeter swans and tundra swans in northwestern Washington state and southern British Columbia (Lagerquist et al. 1994; Degernes et al. 2006). Swan mortalities continue to regularly occur although use of lead shot was prohibited in wetland areas over 10 years previously. The use of lead shot for waterfowl hunting was banned in Whatcom County, Washington in 1989 and Sumas Prairie, British Columbia in 1992 but lead shot continues to be permitted for upland hunting and target shooting and for hunting doves, pigeons, and American woodcock. Lagerquist et al. (1994) found that 35% of 110 trumpeter and tundra swan carcasses collected and diagnosed from 1986 to 1992 had lead liver concentrations diagnostic of lead poisoning. Degernes et al. (2006) found that 81% of 400 trumpeter and tundra swans from carcasses collected from 2000 to 2002 died from

lead poisoning. Swan mortality could be high because swans can forage deeper into bottom sediments than other waterfowl, and be exposed to shot deposited years earlier. Large die-offs or consistent mortality prompt concern that lead poisoning could negatively impact swan populations. From 2000 to 2001, over 300 trumpeter swans died in Whatcom County, Washington alone from ingestion of lead shot (WDFW 2000). The 2001 population of trumpeter swans in this area was 916, so it is likely that lead poisoning is significantly affecting the population in this area.

From 1999 to 2008 more than 2,500 trumpeter (*Cygnus buccinator*) and tundra swans (*Cygnus columbianus*) have died from lead poisoning from ingesting lead shot in northwestern Washington and southwestern British Columbia around just a single lake (Shore 2009; Wilson et al. 2009). Swans at Judson Lake, which straddles the U.S./Canadian border in the Fraser Valley, begin to die from lead poisoning about three weeks after their arrival in November from summer nesting grounds in the Yukon. Swans arrive on the wintering grounds with low blood lead levels, but some birds subsequently become exposed to lead after ingesting lead shot (Smith et al. 2009). Some of the poisoned swans were found to have ingested more than 100 lead shot. Ingestion of only two to three pellets may cause mortality in approximately three weeks. It is unknown whether the swans are ingesting lead shot from feeding on the bottom of the lake, left over from the days before the lead shot ban, or from nearby fields where they also forage, and where lead shot is still legal to use in the hunting of doves and other upland game birds. Relatively high densities of spent lead shot occur in fields and water bodies where hunting and target shooting occur on the U.S. side of Judson Lake (Smith et al. 2009).

Wilson et al. (2009) confirmed lead shot in 80% of intact remains of dead swans from Judson Lake given toxicological testing. A multi-agency working group identified suspected sources of the lead shot, determining the type and size of shot in lead poisoned swans and measuring lead isotope ratios in lead poisoned and non-lead poisoned swans. Patterns of lead ratios in shot from suspected source areas, in shot from gizzards of lead-poisoned swans, and in liver of lead poisoned swans were compared. Swan gizzards had a mix of lead shot sizes typically used for upland game bird hunting (#6) and target shooting (#7.5–8) and predominately non-lead shot sizes typically used for upland game bird hunting (#4–6). Fifty-six percent of the lead ratios measured in the shot collected from sediment/soil fell within the range found for shot collected from the swan gizzards, indicating that swans are not consuming the whole range of shot sizes recovered from agricultural fields and water-bodies. Preliminary results are inconclusive, but Wilson et al. (2009) suspect lead shot for trap or skeet practice in areas frequented by waterfowl may be partially responsible. Two recent tests of hazing or preventing swans from using a major roost site at Judson Lake (2006-2007 and 2007-2008) resulted in a 50% reduction in lead-related swan fatalities, compared to the average of the five previous years (Smith et al. 2009). Judson Lake is a source of the lead shot poisoning swans but it clearly is not the only source.

Efforts to restore trumpeter swans in Wisconsin are also being hampered by persistent die-offs due to lead poisoning, one of the most significant mortality factors for the species. The trumpeter swan was only recently removed from Wisconsin's endangered

species list. According to the Wisconsin Department of Natural Resources (“WDNR”), about 30 percent of all trumpeter swan deaths in Wisconsin are related to lead poisoning from ingesting lead shot or lead fishing sinkers on the bottom of water bodies (Eisele 2008). Of 143 trumpeter swan carcasses submitted to the WDNR for post-mortem examination between 1991 and 2007, 36 deaths (25%) were attributed to lead poisoning. Strom et al. (2009) reported that approximately 25% of trumpeter swan fatalities in Wisconsin have been attributed to lead toxicity, and about 15% of live-sampled trumpeter swans in Wisconsin had blood lead levels above background concentrations (20 µg/dL).

### *Loons*

According to the Wisconsin Department of Natural Resources, about 35 percent of all loon deaths in Wisconsin are related to lead poisoning, from picking up lead shot or sinkers on the bottom of water bodies (Eisele 2008). Pokras et al. (2009) demonstrated that common loons in New England ingest spent lead shot through examining lead objects found in 118 of 522 loon carcasses recovered from the six New England states from 1987 to 2000. A total of 222 lead objects were recorded from the loons’ gizzards, with 11% of the items recovered being lead ammunition, primarily shotgun pellets, but also one .22 caliber bullet and one .44 –.45 caliber bullet. Evers (2004) reported that in New England, a 14-year study diagnosing causes of mortality in 522 common loons documented that 44% of the breeding adults died from lead toxicosis, from either lead shot or sinkers. Substantial rates of lead-related mortality are also known for loons in Michigan, Minnesota and New Hampshire.

### *Eiders*

Lead shot is still used in many parts of rural Alaska for subsistence waterfowl hunting and legal use of lead shot for upland game hunting can occur in waterfowl breeding habitats. Availability of spent shot may be prolonged by permafrost, which frequently underlies wetlands used for breeding and retards the sinking of shot beyond the reach of feeding waterfowl. Lead poisoning of spectacled eiders (*Somateria fischeri*), a federally threatened species, in the Yukon-Kuskokwim Delta of Alaska, has been shown to be due to ingestion of lead shot (Franson et al. 1995; Brown et al. 2006). Spectacled eider breeding pairs on the Yukon-Kuskokwim Delta declined precipitously from about 50,000 in the 1960s to only about 2,000 nesting pairs in 1992 (USFWS 2011).

Radiograph studies showed that nearly 12% of eider adults and 2.5% of eider ducklings had ingested lead shot (Flint et al. 1997; Franson et al. 1998). Adult female eiders died of lead poisoning and predation, and eggs from females exposed to lead survived at much lower rates (Flint and Grand 1997; Grand et al. 1998). More recent studies on the Yukon-Kuskokwim Delta by U.S. Geological Survey and Service biologists revealed that during the breeding season, 36% of adult female spectacled eiders ingested lead shot left in ponds by hunters, and that lead exposure reduced annual eider survival by 50% (USFWS 2011). In some wetland types, lead pellets were still available for birds to eat after more than eight years. The USFWS has ongoing research into whether lead shot is suppressing survival in eiders nesting on the North Slope.

Mortality from lead exposure was suggested as a significant impact impeding the recovery of the local spectacled eider populations in the 1990s, which were already depressed (Grand et al. 1998). Matz and Flint (2009) analyzed blood of spectacled eiders (*Somateria fischeri*), king eiders (*S. spectabilis*), common eiders (*S. mollissima*) and long-tailed ducks (*Clangula hyemalis*) on the Yukon-Kuskokwim Delta and the North Slope of Alaska for total lead and lead isotope ratios. Lead shot can have distinct, ore-specific signatures. Isotopic signatures from birds with relatively high blood lead concentrations were most similar to the isotopic signatures of lead shot, while signatures from birds with low blood lead concentrations closely matched those of local sediments. Lead concentrations in sediment samples were very low, making sediments an unlikely source of the high blood lead concentrations.

## 6. Game Birds

Lead exposure and poisoning from ingesting spent lead shot has been documented in many species of upland game birds such as chukar (*Alectoris chukar*), grey partridge (*Perdix perdix*), ring-necked pheasant (*Phasianus colchicus*), wild turkey (*Meleagris gallopavo*), scaled quail (*Callipepla squamata*), northern bobwhite (*Colinus virginianus*), American woodcock (*Scolopax minor*), ruffed grouse (*Bonasa umbellus*), and mourning dove (*Zenaida macroura*) (Campbell 1950; Damron and Wilson 1975; Best et al. 1992; Yamamoto et al. 1993; Kendall et al. 1996; Akoshegyi 1997; Keel et al. 2002; Battaglia et al. 2005; Butler 2005; Fisher et al. 2006, Schulz et al. 2006).

Mourning doves are particularly at risk for lead poisoning because they frequent and feed at high-risk habitats in terms of high concentrations of spent lead shot (Lewis and Legler 1968; Hass 1977; Kendal and Scanlon 1979a, 1979b; Kendall 1980; Burger et al. 1983; Carrington and Mirarchi 1989; Castrale 1989; Best et al. 1992; Kendall et al. 1996; Burger et al. 1997; Schulz et al. 2002). Portions of the dove populations feeding on these sites ingest lead pellets, and shot ingestion by doves increases during the hunting season (Kendall et al. 1996; Otis et al. 2008; Franson et al. 2009). Virtually all doves that ingest lead pellets succumb to the direct or indirect effects of lead poisoning (Schulz et al. 2006; Schulz et al. 2007). Kendell et al. (2006) identified increased susceptibility to cold as a mortality mechanism caused by lead toxicosis in doves. Spent shot concentrations on managed dove fields have been documented as high as 348,000 pellets per acre (Best et al. 1992).

Sampling and evaluation of lead exposure of hunter-harvested doves is the usual source for estimating lead ingestion (Schulz et al. 2002, 2006) with 2.5- to 45.3% of doves sampled having lead shotgun pellets in their digestive tracts. Schulz et al. (2009) suggested that doves feeding in fields hunted with lead shot that ingest multiple lead pellets may die quickly of acute lead toxicosis and become unavailable to harvest, resulting in an underestimates of lead shot ingestion rates, such as for previous studies finding relatively few doves with ingested lead shot despite feeding in areas with high lead shot availability. Schulz et al. (2007, 2009) administered lead shot to captive doves and confirmed rapid and acute lead toxicosis.

Franson et al. (2009) evaluated lead exposure in 4,884 hunter-harvested mourning doves from Arizona, Georgia, Missouri, Oklahoma, Pennsylvania, South Carolina, and Tennessee. The frequency of ingested lead pellets in gizzards of doves on hunting areas where the use of lead shot was permitted was 2.5%. On areas where non-lead shot was required, 2.4% of mourning doves had ingested steel shot. Doves without ingested lead pellets had lower bone lead concentrations in areas requiring the use of non-lead shot than in areas allowing the use of lead shot. Schulz et al. (2006) calculated from comparing hunting statistics and population estimates that nearly as many doves are poisoned lethally by ingesting lead shotgun pellets (8.8 million to 15 million per year) as are shot by sport hunters on an annual basis. The number of mourning doves harvested in the U.S. is approximately 20 million birds annually.

Bingham et al. (2009) documented ingestion of lead pellets by hunter-harvested chukars in four counties in western Utah, finding ingested lead pellets in 8.74% of gizzards from 286 birds. Toxicology results show elevated concentrations of lead (>0.5 ppm, ranging from 0.7 to 42.6 ppm) in 50 bird livers (14%). The arid, rocky, and alkaline nature of chukar habitat reduces pellet settlement and dissolution, and the similar appearance of lead pellets to chukar food sources leads to ingestion of lead pellets by chukars.

American woodcock are exposed to lead on their breeding grounds in Wisconsin, resulting in high accumulations of lead in bone tissue (Strom et al. 2009). Bone lead concentrations considered to be toxic in waterfowl were observed in all age classes of woodcock; although stable isotope analysis of bone samples was not able to conclusively identify the source of the lead, the data suggest a local and dietary source (Strom et al. 2009).

## **7. Cranes and Rails**

A number of gruiformes have been shown to ingest lead shot, including greater sandhill cranes (*Grus canadensis tabida*), American coots (*Fulica americana*), clapper rails (*Rallus longirostris*), king rails (*Rallus elegans*), Virginia rails (*Rallus limicola*), and sora (*Porzana carolina*) (Jones 1939; Kennedy et al. 1979; Windingstad et al. 1984; Franson and Hereford 1994; Wingstad 1998; Fisher et al. 2006). The consequences of poisoning incidents for the critically endangered Mississippi sandhill crane (*Grus canadensis pulla*) could be considerable, given a population that has only recently grown to about 100 individuals (Johnsgard 1983; LaRoe et al. 1995). Whether endangered whooping cranes (*Grus americana*) ingest lead pellets during their migration across Canada and the U.S. is unknown.

## **8. Corvids**

Scientists tested blood lead levels in 302 ravens that scavenged on hunter-killed large ungulates and their offal in and around Grand Teton National Park, Wyoming in 2004 and 2005 (Craighead and Bedrosian 2007, 2008). Blood-lead levels of ravens increased dramatically during hunting season, roughly five times higher than the rest of the year,

likely due to ravens consuming lead bullet fragments left behind in gut piles of hunted elk, deer and moose. Blood samples were taken during a 15-month period spanning two hunting seasons, from mid-September 2004 to mid-December 2005. Forty-seven percent of the ravens tested during the hunting season exhibited elevated blood lead levels ( $\geq 10$   $\mu\text{g}/\text{dL}$ ) while only 2% tested during the non-hunting season exhibited elevated lead levels. Offal is the primary food source of ravens during the time of exposure and Craighead and Bedrosian (2007) also identified un-retrieved offal piles of hunter-killed game as a point source for lead contamination in the area. These substantial increases in blood-lead levels correspond almost exactly with the open and close of hunting season. Just after the start of hunting season, blood-lead levels begin to rise. Shortly after the end of hunting season, they return to normal. Blood-lead levels show a spike again in the late spring, when melting snow uncovers gut piles left from the previous hunting season. One hundred percent of the ravens at the study site feed on gut piles at some point throughout the hunting season and get exposed to lead.

Craighead and Bedrosian (2009) collected an additional 237 blood samples from ravens in the same study area spanning an additional two hunting seasons. The samples had a median blood lead level of 10.0  $\mu\text{g}/\text{dL}$  with a range of 2.7–51.7  $\mu\text{g}/\text{dL}$ . The median blood lead level of 84 additional samples collected during the non-hunting season was only 2.2  $\mu\text{g}/\text{dL}$  with a range of 0.0–19.3  $\mu\text{g}/\text{dL}$ . Fifty percent of the hunting season samples had blood lead levels  $>10\mu\text{g}/\text{dL}$ , while only 3% were greater than  $10\mu\text{g}/\text{dL}$  during the non-hunting season.

Craighead and Bedrosian also documented that the blood lead levels of ravens around Grand Teton dropped corresponding with increased use of non-lead ammunition by hunters on the National Elk Refuge and in Grand Teton National Park. In fall of 2009 researchers distributed 194 boxes of copper bullets to hunters with permits for the park and the refuge, captured 46 ravens (which typically scavenge the discarded gut piles) during hunting season and tested their blood for lead. An estimated 24% of hunters in the area used copper bullets in 2009, and there was a corresponding 28% drop in blood lead levels in ravens compared with what would have been expected (Hatch 2010).

Research has yet to be done on lead exposure to magpies, which occasionally feed on carrion and could also ingest lead by eating hunter-killed carcasses.

## 9. Song Birds

Lead poisoning from ingested spent lead ammunition has been documented in several songbird species in the United States, including white-throated sparrow (*Zonotrichia albicollis*), dark-eyed junco (*Junco hyemalis*), brown-headed cowbird (*Molothrus atar*), yellow-rumped warbler (*Dendroica coronata*), brown thrasher (*Toxostoma rufum*) and blue-headed vireo (*Vireo solitarius*) (Vyas et al. 2000, 2001; Lewis et al. 2001).

## 10. Mammals

Elevated levels of lead have been found in several species of small mammals near shooting ranges, such as shrews, mice, voles, and squirrels, hares, opossums and raccoons (Tataruch and Onderscheka 1981; Erickson and Lindsey 1983; Ma 1989; Stansley and Roscoe 1996; Lewis et al. 2001). It was not determined whether elevated blood lead levels were due to direct ingestion of lead particles, or whether plants growing on lead-contaminated soil bioaccumulated lead, which was then ingested by the herbivorous mammals. Woolf et al. (1982) identified lead in liver of wild white-tailed deer (*Odocoileus virginianus*).

Ingestion of lead by carrion scavenging mammals, such as coyotes, grizzly bears, black bears, wolves, wolverines and mountain lions feeding on varmint carcasses, and gut piles and carcasses of big game during the hunting season has rarely been studied. Large carnivores such as black bears (*Ursus americanus*), grizzly bears (*U. arctos*), wolves (*Canis lupis*) and coyotes (*C. latrans*) scavenge to varying degrees on ungulate offal piles abandoned by hunters. Cougars (*Puma concolor*) may periodically be exposed to lead at biologically significant levels because of the tendency to occasionally scavenge. Rogers et al. (2009) have begun collecting samples of liver, hair, blood, and feces from black and grizzly bears, wolves, coyotes and cougars in Grand Teton, Wyoming, and tested samples for the presence of lead. Rogers et al. (2009) documented elevated lead blood levels in grizzly bears during hunting season, when they scavenge the remains of big game. Preliminary data by Rogers et al. (2009) showed that of 13 Grand Teton grizzly bears sampled during hunting season, 46% showed elevated blood lead levels above 10 µg/dl, while 11 bears sampled outside of hunting season had undetectable lead in their blood. The potential consequences for large mammalian scavengers are as yet unstudied.

## 11. Amphibians and Reptiles

A few studies have found elevated concentrations of lead in tissues of amphibians and reptiles near shooting ranges and heavily hunted areas (Stansley and Roscoe 1997; Stansley et al. 1997; Hammerton et al. 2003; Pattee and Pain 2003), with exposure presumed to be due to ingestion of lead in food items or dissolved in water, although ingestion of small lead fragments may be possible. Lead poisoning has been shown to cause mortality and to impact egg and tadpole development and growth rates in amphibians (Dilling and Healey 1926; Kaplan et al. 1967; Khangarot et al. 1985; Perez-Coll et al. 1988; IPCS 1989; Stansley et al. 1997; Rice et al. 1999; Sparling et al. 2006). American alligators have been documented ingesting lead bullets after feeding on nutria that had been shot (Camus et al. 1998).

### F. Toxic Effects of Lead Ammunition on Humans

The toxic effects of lead on humans have been known since Roman times (Nriagu 1983; Needleman 1999; Hernberg 2000; Tong et al. 2000; Nriagu 2009). Lead is an extraordinarily toxic element, and when ingested it attacks organs and many different body systems, including the blood-forming, nervous, urinary, and reproductive systems



(USDHHS 1999). Lead accumulates in humans mainly in bones, with lead in blood and other tissues reflecting more recent exposure. The effects of lead poisoning can include: damage to the brain and central nervous system; kidney disease; high blood pressure; anemia; and damage to the reproductive system, including decreased sex drive, abnormal menstrual periods, impotence, premature ejaculation, sterility, reduction in number of sperm cells, damage to sperm cells resulting in birth defects, miscarriage, and stillbirth, painful gastrointestinal irritation, diarrhea, loss of appetite, weakness and dehydration, nerve disorders, memory and concentration problems, muscle and joint pain (USDHHS 1999).

In large enough doses, lead can cause brain damage leading to seizures, coma, and death (USDHHS 1999). Chronic overexposure to low levels of lead can cause health impairments to develop over time, and irreversible damage can occur without obvious symptoms (USDHHS 1999). Lead exposure can adversely affect the nervous system (resulting in impaired cognition, reduced motor coordination, and palsy), renal system, and cardiovascular system (IPCS 1977; Needleman et al. 1990; Goyer 1996; Needleman 2004; Khan 2005; Cecil et al. 2008). Lead is also implicated in decreased growth (Hauser et al. 2008), decreased brain volume (Cecil et al. 2008), spontaneous abortion (Borja-Aburto et al. 1999), kidney damage (Ekong et al. 2006), cancer, and cardiovascular disease (Menke et al. 2006, Lustberg and Silbergeld 2002). Lead is especially dangerous to fetuses and young children and poisoning is even more pronounced because the lead is absorbed faster and disrupts development, causing slow growth, development defects, and damage to the brain and nervous system (Schnaas et al. 2006). Some studies link elevated bone or blood lead levels with aggression, delinquent behavior, attention deficit hyperactivity disorder and criminal behavior (Nevin 2000; Needleman et al. 2002; Needleman 2004; Braun et al. 2006; Wright et al. 2008).

Many studies show that lead exposure is harmful and that even very small amounts of lead can have permanent, debilitating, sub-lethal effects. In humans, blood lead concentration of 10 micrograms of lead per deciliter ( $\mu\text{g}/\text{dl}$ ) is currently considered an elevated level, although some researchers and health professionals have advocated for a threshold of 5 micrograms or even 2 micrograms. In the mid-20th century, the amount of lead in the bloodstream of a child considered in need of medical intervention was considered to be 60  $\mu\text{g}/\text{dl}$ , whereas today it is 10  $\mu\text{g}/\text{dl}$ . The U.S. Department of Health and Human Services has concluded that there is evidence that blood lead levels less than 10  $\mu\text{g}/\text{dl}$  are associated with adverse health effects on development in children and reproduction in adult women, such as delayed puberty, decreased postnatal growth, reduced fetal growth, spontaneous abortion and preterm birth (NTP 2011); and studies show blood lead levels at and below 2  $\mu\text{g}/\text{dl}$  are associated with adverse effects (e.g. Wu et al. 2003; Denham et al. 2005). Children sustain permanent cognitive damage when showing a blood lead average of only 7.5  $\mu\text{g}/\text{dl}$  before the age of five (Lanphear et al. 2005). The consensus among medical researchers is that there is no safe level of lead exposure in young children (CDC 2005).

Human exposure to lead in the United States has decreased as lead plumbing, paint, solder, toys, and gasoline have been phased out and replaced. Public health agencies have

regulated lead in industrial activities and consumer products, and have to varying degrees begun to address and remediate lead exposure from shooting ranges, but have focused little attention on hunting or fishing activities that may be an important source of lead exposure in certain communities, occupations or activities.

Hunters who use lead bullets are at risk of lead poisoning in several ways. One exposure mechanism is inhalation of airborne lead created by friction from lead slugs against the gun barrel (KDHE 2004), whereby inhaled lead enters the bloodstream and is distributed throughout the body. Hunters who handle lead bullets are also at risk of ingesting lead residue (KDHE 2004). The most serious exposure is from accidental ingestion of lead shot pellets or lead bullet fragments in the meat (Carey 1977; Tsuji et al. 1997, 1999; Scheuhammer et al. 1998; Johansen et al. 2001, 2004, 2005; Bjerregaard et al. 2004; Mateo et al. 2007). Health effects in human beings following ingestion of whole lead shot pellets have been reported in many cases, and ingestion of meat tissues containing minute flakes or fragments of metallic lead from the passage of lead shot or lead bullet fragments through the tissues is also possible (Scheuhammer and Norris 1995; Khan 2005).

Published literature on lead concentrations and lead isotope patterns from subsistence hunters in the circumpolar North indicates that elevated human lead exposure is correlated with use of lead ammunition (Verbrugge et al. 2009). The mechanisms of exposure include ingestion of lead dust, ammunition fragments, and shot pellets in harvested meat, and inhalation of lead dust during ammunition reloading. Epidemiological studies and risk assessment modeling indicate that regular consumption of game meat harvested with lead ammunition and contaminated with lead residues may cause relatively substantial increases in blood lead compared to background levels, particularly in children (Kosnett 2009). A Canadian study of blood lead levels in hunters (Nieboer 2001) showed that lead pellets from wild game harvested with lead shot is a major source of exposure to lead in Native American communities in Canada. Blood lead levels were demonstrated to be higher in Native hunting communities than in a nearby reference group. Blood lead levels were also higher in men than women, consistent with greater participation of males in hunting and greater consumption of bagged wild fowl. Blood lead levels were shown to increase in male hunters during the hunting season, and one of the measured lead isotope ratios also changed in a manner consistent with exposure to lead derived from leaded ammunition. Of 132 subsistence hunters radiographed, 15% showed ingested lead pellets, with 8% located in the lumen of the digestive tract and 7% in the appendix (Tsuji and Nieboer 1997). Fifteen recent studies in Canada, Greenland, and Russia have linked lead shot found in game animals to higher levels of lead in people who eat those game animals (Carey 1977; Tsuji et al. 1997, 1999; Scheuhammer et al. 1998; Johansen et al. 2001, 2004, 2005; Bjerregaard et al. 2004; Mateo et al. 2007; Tranel and Kimmel 2009). Studies showing significantly higher lead exposure in people from hunting communities have major implications for the public health hazards of lead in ammunition (Dewailley et al. 2001; Levesque et al. 2003).

In Alaska, ammunition-related lead exposures include ingestion of lead fragments in shot game, use of certain indoor firing ranges and melting and casting lead to make bullets. Titus et al. (2009) quantified the population of Alaska at potential risk of lead exposure

from eating game shot with lead ammunition. Alaska has 84,000 licensed resident hunters, many of whom rely on wild game for a significant part of their diet. About 29,000 hunters kill about 7,300 moose annually in Alaska. In rural Alaska, where reliance on ungulate meat is high, about 100 kg of moose and caribou meat is consumed per person annually, and small game, marine mammals, and waterfowl harvested with firearms also contribute to the local diet. Sixty percent of households in rural Alaska harvest game animals and 86% consume wild game.

A study of lead concentrations in tissues of waterfowl killed by lead shotgun pellets (Frank 1986) showed high amounts of lead (>100 mg/kg) and confirmed the presence of lead fragments by X-ray. Particles of lead ranged from irregular fragments 1–2 mm in length to very fine dust, resulting from the disruption of lead shot pellets upon collision with bone (Frank 1986). Researchers have also detected lead fragments visible by radiograph in carcasses of squirrels shot with bullets (Harmata and Restani 1995; Knopper et al. 2006). The flesh of any species of game animal killed with lead shot or lead bullets can become contaminated with high concentrations of lead through this mechanism. Studies have demonstrated that lead bullets can shatter into hundreds of fragments when fired from a high-powered rifle (Hunt et al. 2009b; Cornicelli and Grund 2009). Bedrosian and Craighead (2009) showed extensive fragmentation of lead bullets in an elk carcass shot with a .30-06 rifle. In an X-ray of the results, lead fragments appear as white shards spread throughout a large area in the elk's body. Hunt et al. (2009b) found that lead fragments in shot game spread far beyond the internal organs and can move into the meat that humans eat. X-rays of meat from a butchered game animal showed bullet fragments in steaks packaged for human consumption. While most big-game hunters discard "blood-shot" meat that has been pierced by bullet fragments, the California research shows that fragments can be packaged even by experienced butchers.

A study by the Minnesota Department of Natural Resources found that when lead bullets explode inside an animal, imperceptible dust sized particles of lead can infect meat up to a foot and a half away from the bullet wound (Cornicelli and Grund 2009). Cornicelli and Grund (2009) conducted a radiograph study of bullet fragmentation patterns in carcasses to determine the potential risk of lead contamination of deer meat in the Minnesota venison donation program. The study assessed lead levels in deer and domestic sheep shot using different types of bullets and firearms commonly used for hunting in Minnesota, including: a centerfire rifle with lead bullets designed to rapidly expand upon impact used for hunting mid-sized game such as deer, lead bullets designed to retain a high percentage of their weight, and non-lead copper bullets; a shotgun using a 1-ounce Foster lead slug, commonly used throughout the Minnesota shotgun-only zone; and an inline muzzleloader with two common bullet types used during Minnesota's hunting seasons.

Cornicelli and Grund (2009) showed that using bullets with no exposed lead (a copper case completely surrounds the lead core) or bullets made of copper significantly reduce (or eliminate) lead exposure. Non-exposed lead core bullets averaged nine copper fragments in the animal with an average maximum distance from the wound channel of seven inches. By design, copper bullets leave no lead and the few copper fragments that

were seen on x-ray were less than an inch from the exit wound. Both of these bullet designs fragmented very little and left no lead. Ballistic tip lead bullets (rapid expansion) had the highest fragmentation rate, with an average of 141 lead fragments per carcass and an average maximum distance of 11 inches from the wound channel. In one carcass, a lead fragment was found 14 inches from the exit wound. Soft point lead bullets (rapid expansion) left an average of 86 lead fragments at an average maximum distance of 11 inches from the wound channel. Bonded lead-core bullets (controlled expansion, exposed lead core) left an average of 82 lead fragments with an average maximum distance of nine inches from the wound. Lead shotgun slugs left an average of 28 lead fragments at an average maximum distance of five inches from the wound channel. Muzzleloader bullets (245-grain and 300-grain respectively) left an average of three and 34 lead fragments, respectively, at an average maximum distances of one and six inches, respectively. Lead fragments were found so far from exit wounds that routine trimming likely would not remove all of the fragments. Only about 30% of fragments were within two inches of the exit wound, and the vast majority were dispersed further from the carcass. In some cases, low levels of lead were detected as far away as 18 inches from the bullet exit hole. Rinsing of a carcass produced mixed results, tending to reduce lead around the wound channel but also transporting lead away from the wound. Lead ammunition shot into the hindquarters of a deer, where heavy bones are found, resulted in extensive fragmentation so pronounced that a hunter would likely not want to utilize this meat as there would be no way to remove all the fragments. Having venison processed at a meat processor will likely result in an increased risk of lead exposure because venison from different hunters is typically mixed during the grinding process and the vast majority of hunting bullets are made from lead. Cornicelli and Grund (2009) found that 27% of the ground venison and 2% of the whole muscle cuts tested had detectable lead fragments.

In a highly publicized recent case, packets of venison shot with lead ammunition and donated by hunters to feed the hungry tested positive for lead contamination. Cornatzer et al. (2009) studied 100 randomly selected ground venison packages donated to the Community Action Food Centers of North Dakota by hunters. The packages were studied by high resolution computerized tomography imaging and x-ray fluoroscopy for detection of metal fragments. Analysis of randomly selected ground venison samples showed 59 packages out of 100 (59%) had one or more visible lead fragments. One sample had 120 ppm lead. Cornatzer et al. (2009) concluded there is a health risk from lead exposure to humans consuming ground venison. Food banks and shelters in North Dakota pulled the meat from their shelves after the report. The Centers for Disease Control and Prevention and the North Dakota Department of Health ran a test to find out the health effects of lead-shot game. The agency compared blood-lead levels of people who regularly eat meat shot with lead bullets with the levels of those who don't eat much wild game. The results were inconclusive. Those who ate the lead-shot meat had slightly higher blood-lead levels than those who did not, but none of the 738 people in the study had levels above the government's threshold for danger. The health department recommended that children younger than 6 and pregnant women stop eating venison shot with lead bullets because those groups are at particular risk for lead poisoning, even at low levels. Avery and Watson (2009a) conducted a survey of all wild game meat donation programs throughout

the United States to determine the amount of venison and other game donated annually. Venison donation programs operate in all 50 states and in at least four Canadian provinces. For the 2007/2008 hunting season 75 programs reported providing an average of 34,943 pounds of hunted game meat annually, a total of 2.6 million pounds of meat or approximately 10 million meals.

Hunt et al. (2009) radiographed 30 eviscerated carcasses of white-tailed deer (*Odocoileus virginianus*) shot by hunters with standard lead core, copper-jacketed bullets under normal hunting conditions. All deer carcasses brought to processors contained fragments (15–409 fragments counted in radiographs), and despite a high rate of removal of fragments by processors to avoid contamination, 80% were unable to do so entirely. Hunt et al. (2009) demonstrated that people risk exposure to bioavailable lead when they eat venison from deer killed with standard lead-based rifle bullets and processed under normal commercial procedures. Ten million hunters, their families, and low-income beneficiaries of venison donations in the U.S. are at risk. The evidence includes a high proportion (80%) of examined deer showing at least one bullet fragment in one or more ground meat packages, a substantial frequency of contamination (32% of all ground meat packages), a majority (93%) of assayed fragments identified as lead, isotopic homogeneity of bullet lead with that found in the meat, and increased blood lead concentrations in swine fed fragment-containing venison, meaning the lead is bioavailable to humans as well. Hunt et al. (2009) concluded that in a majority of cases, one or more consumers of a hunter-killed, commercially-processed deer will consume toxic lead derived from bullets.

Pain et al. (2010) found that eating the meat of animals hunted using lead ammunition can be more dangerous for health than was previously thought, especially for children and people who consume large quantities. Pain et al. (2010) analyzed the meat of six species of game birds (red partridge, pheasant, wood pigeon, grouse, woodcock and mallard) shot by hunters in the United Kingdom, and found that lead levels in cooked game meat exceeded the maximum allowances set by the European Union, due to the presence of remains of ammunition, even after lead pellets were removed. Depending on the species and type of recipe used, between 20% and 87.5% of the samples analyzed exceeded 100 parts per billion of the fresh weight of meat.

Watson and Avery (2009) assessed the numbers and proportions of state populations that hunt and may be at risk of lead exposure from lead-based ammunition, from handling lead ammunition (hunters who load their own ammunition), inhalation of vapor upon firing, or ingestion of game meat contaminated with bullet fragments and shot. In 2006, 12.5 million people (6% of the population) aged 16 years and older in the United States hunted on 220 million days, including an estimated 1.6 million children aged 6 to 15 years.

Elevated blood lead levels resulting in biochemical effects, disease and neurotoxicity have been documented for people who frequent or work at indoor and outdoor firing ranges (Fischbein et al. 1979; Novotny et al. 1987; Chisholm 1988; Valway et al. 1989; Peddicord and LaKind 2000; Gulson et al. 2002). Exposure may be due to handling lead

materials during reloading as well as inhalation of lead dust. Sportsmen who reload rifle and pistol ammunition and cast their own lead bullets are at particular risk of exposure to lead.

## V. AUTHORITY TO ACT

In 2010, the EPA denied a petition under the Toxic Substances Control Act (“TSCA”) seeking a complete ban on all lead ammunition. In denying that petition, the EPA stated that “TSCA does not provide the agency with authority to address lead shot and bullets as requested in your petition, due to the exclusion found in TSCA § 3(2)(B)(v).”

However, Senate and House reports on the legislative history and intent of TSCA, not included in the 2010 petition and not considered by the EPA in its denial, confirm that the agency indeed does have the regulatory authority to regulate the toxic components of ammunition. According to the House report on the history and intent of TSCA, “the Committee does not exclude from regulation under the bill chemical components of ammunition which could be hazardous because of their chemical properties.”

The legislative history of TSCA supports its plain language. Section 2605(a)(2)(A)(i) of TSCA, passed in 1968 as the federal mechanism for regulating toxic substances, allows the EPA to regulate any chemical substance for a particular use, up to and including prohibiting the manufacture, processing or distribution in commerce. Lead is plainly a “chemical substance” falling within the scope of TSCA. Although certain products are excluded from the definition of “chemical substances,” none of these exclusions are applicable to lead bullets or shot.

In adopting TSCA, Congress declared its policy that (1) “adequate data should be developed with respect to the effect of chemical substances and mixtures on health and the environment” and (2) “adequate authority should exist to regulate chemical substances and mixtures which present an unreasonable risk of injury to health or the environment.”

If “there is a reasonable basis to conclude that the issuance” of a proposed rule “is necessary to protect health or the environment against an unreasonable risk of injury to health or the environment,” then the EPA must grant a petition for rulemaking and initiate rulemaking procedures under TSCA section 2605. (15 U.S.C. § 2620(b)(4)(B)(ii)). Factual certainty of the magnitude of risk to health and environment is not required; the EPA may base its decision not only on known facts, but also on scientific theories, projections and extrapolations from available data, and modeling using reasonable assumptions (59 Fed. Reg. 11122, 11138, citing H.R. Rep. No. 1341, 94<sup>th</sup> Cong., 2d Sess. 32 (1976)).

Lead used in shot and bullets is a “chemical substance” falling within the scope of the Act (15 U.S.C. § 2602(2)(A)).<sup>1</sup> Although certain substances are excluded from the definition of “chemical substances,” these exclusions do not apply to lead shot or bullets. The relevant section of TSCA, (15 U.S.C. § 2602(B)). Section 2602(B)(v), excludes from

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<sup>1</sup> “Except as provided in subparagraph (B), the term “chemical substance” means any organic or inorganic substance of a particular molecular identity, including (i) any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature and (ii) any element or uncombined radical.”

Act regulation “any article the sale of which is subject to the tax imposed by section 4181 of the Internal Revenue Code of 1986.” However, Section 4181 of the Internal Revenue Code only taxes firearms, shells, and cartridges (26 U.S.C. § 4181). Shot and bullets are explicitly not subject to this tax. In fact, a 1968 Revenue Ruling states, “The manufacturers excise tax imposed upon sales of shells and cartridges by section 4181 of the Internal Revenue Code of 1954 **does not apply** to sales of separate parts of ammunition such as cartridge cases, primers, bullets, and powder” (Rev. Rul. 68-463, 1968-2 C.B. 507 (emphasis added)). This ruling has been confirmed by subsequent administrative decisions (See, for example, Fed. Tax Coordinator ¶ W-2911(2d.)). Because shot and bullets, as separate parts of ammunition, are not listed as taxable items in 26 U.S.C. § 4181, and additional evidence affirms they are not implicitly taxed under section 4181, the section 2602(B)(v) exception of TSCA to “chemical substance” does not apply. Thus, lead shot and bullets are properly classified as “chemical substances” subject to TSCA regulation.

The Senate and House reports on the legislative history and intent of TSCA are equally clear and instructive. The House report explicitly states on page 418: “Although the language of this bill is clear on its face as to the exemption for pistols, revolvers, firearms, shells and cartridges, the Committee wishes to emphasize that it does not intend that the legislation be used as a vehicle for gun control...However, ***the Committee does not exclude from regulation under the bill chemical components of ammunition which could be hazardous because of their chemical properties***” (emphasis added). The Senate report states, “In addition, the term [chemical substance] does not include pesticides, tobacco, or tobacco products, nuclear material (as defined in the Atomic Energy Act), firearms and ammunition (to the extent subject to taxes imposed under section 4181 of the Internal Revenue Code)...”

The IRS ruling, along with the legislative history of TSCA, makes clear that the component parts of ammunition, namely shot and bullets, may be regulated as chemical substances under TSCA. This petition does not request that the EPA regulate firearms or the manufacture and sale of ammunition, but rather the toxic, separate parts of ammunition, such as bullets and shot.



## VI. ALTERNATIVES TO LEAD AMMUNITION

In reviewing this petition, the EPA is only required to determine whether there is a reasonable basis to conclude that an issuance of such a rulemaking is necessary to protect against an unreasonable risk of injury. However, in promulgating a rule in response to a Section 6 petition, the EPA must consider “the benefits of such substance or mixture for various uses and the availability of substitutes for such uses” as well as “the reasonably ascertainable economic consequences of the rule, after consideration of the effect on the national economy, small business, technological innovation, the environment, and public health” (15 U.S.C. § 2605(c)(1)(C)-(D)). Therefore, this petition identifies commercially available alternatives to rifle bullets, rimfire bullets and shotgun pellets containing lead. Not all products available in lead are currently available as non-lead alternatives, but a rapidly increasing number and range of bullets in all calibers are available in non-lead forms, and demonstrated technology indicates that hunting and shooting sport products could be produced in non-lead alternatives within a short period of time if manufacturers are provided a transition period for expanding upon current designs and stocks of ammunition.

Stroud and Hunt (2009) reviewed basic bullet materials available to bullet manufacturers, which include lead alloys, lead with external copper wash, lead core with copper jacket, pure copper, and bismuth. Lead and bismuth are highly frangible, whereas pure copper bullets tend to remain intact after impact. Bullet fragmentation increases the degree of lead contamination in tissue ingested by scavengers feeding on hunter-killed animal remains. Modern bullet design, velocity, composition, and bone impact are significant factors in the character and distribution of lead particles in carcasses, gut piles, and wound tissue left in the field by hunters. Prior to the 1900s, bullets were made entirely of lead. Their velocities were relatively slow (<2,000 feet per second), and their tendency to fragment was accordingly lower than that of modern ammunition. Development of smokeless powder in the 1890s increased bullet speeds above 2,000 feet (610 m) per second, causing lead bullets to melt in the barrels and produce fouling which reduced accuracy. Copper jacketed lead-core bullets were therefore developed, which permitted velocities that may exceed 3,000 or even 4,000 ft/sec in modern firearms. Standard hunting bullets now typically travel at 2,600 to 3,100 ft/sec, speeds highly conducive to fragmentation. Plastic-tipped “hollow-point bullets” used for varmint hunting are actually designed to completely fragment, leaving the entire mass of the lead bullet to contaminate the carcass.

Although the terms “lead-free,” “non-lead” and “nontoxic” are often used interchangeably, they are not equivalent. As a result of the manufacturing process, trace levels of lead can exist in any metal projectile used for bullets, including copper, resulting in ammunition that is not 100% lead-free, but that is functionally nontoxic to wildlife and humans. The U.S. Fish and Wildlife Service (“USFWS”) definition of “nontoxic” shot to be used in waterfowl hunting specifies in 50 C.F.R. 20.21(j) several alloys containing not more than 1% lead. Steel shot can be coated with metals such as zinc (which always contains lead as an impurity) as long as the coating does not exceed 1% of the weight of the shot. The California Department of Fish and Game has established a maximum

amount of lead content in projectiles considered to be nontoxic at 1% by weight, given scientific consensus that this threshold for lead content will preclude risk from lead fragmentation to California condors, which are typically more sensitive to lead than other taxa. Toxicological modeling of this amount of lead impurity in bullet fragments indicates that even if condors consume major fragments of bullets, the dissolution of lead is unlikely to raise the blood lead levels above 1 µg/dL, a low level equivalent to the blood lead levels of condors being raised in Los Angeles or San Diego Zoos on a lead-free diet (Fry et al. 2009). Other metals used for manufacturing ammunition can have risk of toxicity, which is a function of exposure and concentrations, and the resulting dose encountered by wildlife or humans that ingest ammunition fragments or shot pellets. For example, tungsten, although considerably less toxic than lead, can be oxidized in the environment forming tungstate and can migrate into ground water. Tungstate can cause immuno-suppression at high concentrations. Although tungstate and tungstate alloys (with the exception of tungsten/nickel/cobalt, which when imbedded can cause a rare cancer, rhabdomyosarcoma) are much less toxic than lead, they are not truly “non-toxic.” Another example is copper-jacketed lead, which can facilitate the galvanic oxidation of metallic lead to more environmentally and bioavailable forms such as lead oxides and carbonates, effecting transport into the food web.

For all but the smallest caliber bullets (those used for varmint hunting), non-lead ammunition is widely available. Currently available alternatives are either made completely of non-lead materials, such as copper; or designed such that a lead interior is “jacketed” by copper and theoretically protected from exposure upon impact. Other designs have been proposed and it is expected that the increase in demand will result in greater options of non-lead ammunition. Non-lead bullets generally have equivalent, if not superior, performance when compared to their lead counterparts. Copper bullets were originally designed for the “premium” market not because of concerns over lead poisoning but rather for their enhanced ballistic capabilities.

Oltrogge (2009) reviewed the success of ammunition manufacturers in developing non-lead, expanding-nose centerfire bullets. The Barnes Bullet Company succeeded in 1985 in designing copper bullets that demonstrate good expansion without shedding copper particles. They have proper rotational moment of inertia, are made in traditional bullet weights, and despite the lower density, the over-all loaded cartridge lengths are within specification. These and other factors make them as capable as traditional lead-cored bullets. They are on the market as the X-Bullet series, in several varieties, chief of which are the Triple Shock and the MRX. The latter is shorthand for Maximum Range X-Bullet, which has an all-metal tungsten-composite core that is more dense than lead. It shoots further, with flatter trajectory, than any other non-lead bullet and surpasses many lead-containing bullets. Oltrogge (2009) reviewed some of the science of achieving these non-lead, centerfire bullets. Nosler and other companies are now making all-copper centerfire bullets, and availability is increasing.

Currently there are a number of copper hunting bullets produced, at least one of which—the Barnes X Bullet—is widely available. The Barnes X is made out of copper, a material that is lighter and more rigid than lead. Barnes produces a number of X-type bullets,

including the X, XLC, and Triple Shock X, in a wide variety of calibers suitable for hunting game such as deer, elk, pig, and coyote. In order to promote proper expansion, Barnes bullets are designed with a hollow point that is fluted so that the tip peels back to form a mushroom upon impact. Barnes bullets have a ballistic coefficient between .220 and .555, depending upon the caliber and cartridge used. Barnes also reports that its bullets retain close to 100% of their weight after hitting most targets. Thus, Barnes bullets are a non-lead alternative ammunition that offers equivalent or superior performance to that of high-quality lead bullets. Another alternative bullet, composed of tungsten, tin, and bismuth (“TTB”) is being developed by various ammunition manufacturers and the military has been experimenting with a so-called “green” bullet that relies on the same metals to replace lead (Mikko 1999).

The California Department of Fish and Game (“CDFG”) certifies “nontoxic” ammunition for use while hunting big-game and non-game species in the range of the California condor in California, including deer, bear, wild pig, elk, pronghorn antelope, coyote, ground squirrels, and other nongame wildlife. Such ammunition must use a projectile or bullet which has been certified to contain  $\leq 1\%$  lead by weight. As a result of the manufacturing process, trace levels of lead are likely exist in any projectile made of any metal. CDFG established a maximum amount of lead content in projectiles to be 1% by weight, given scientific consensus that this threshold for lead content will preclude risk to the condor from lead fragmentation. Typically, the certified “nontoxic” identified projectiles have far less than 1% lead content. As of April 2010, CDFG had certified “nontoxic” ammunition from 24 manufacturers. A list of CDFG approved “nontoxic” ammunitions can be found at

<http://www.dfg.ca.gov/wildlife/hunting/condor/certifiedammo.html>. The Arizona Game and Fish Department also publishes a list of non-lead rifle ammunition available for big game hunters, including 120 bullets in various calibers produced by 13 ammunition manufacturers, as well as 7 manufacturers who provide custom-loaded non-lead rifle ammunition. The information can be found at [http://www.azgfd.gov/pdfs/w\\_c/condors/Non-LeadAmmo.pdf](http://www.azgfd.gov/pdfs/w_c/condors/Non-LeadAmmo.pdf).

Both rifle bullets and .22 caliber rimfire bullets are currently marketed with non-lead alternatives. Non-lead ammunition in .22 rimfire was made available only after California required the use of “nontoxic” .22 ammunition in the range of California condors. Prior to that time, expert testimony was presented to the California Fish and Game Commission claiming that non-lead .22 caliber rimfire was impossible to produce. However, commercially available non-lead .22 caliber ammunition was available four months after the Commission decision to ban lead .22 ammunition.

In one survey, 90% of hunters and ranchers surveyed approved of the use of copper bullets (Ritter 2006). According to post-hunt survey results in Arizona, 88% of successful hunters who used non-lead ammunition said it performed as well as or better than lead bullets; in addition, 72% of all hunters said they would recommend the all-copper bullets to other hunters (Seng 2006). In general, experts appear to endorse the use of non-lead bullets (AGFD 2010a, 2010b; Rees 2010).

Non-lead shotgun ammunition is widely available on the market, largely as the result of federal regulations requiring its use while hunting for waterfowl (50 C.F.R. § 20.134). Certification of “nontoxic” shot for waterfowl hunting is conducted by the USFWS, and acceptable alloys must be not more than 1% lead. Shotguns, the dominant firearm used for waterfowl hunting, are also used for upland hunting of small game, such as squirrels, rabbits, and birds, and in many states are used for hunting larger game such as deer and pigs using solid slugs.

Commercially available non-lead shotgun ammunition consists of shot composed either of steel, tungsten (including tungsten-iron, tungsten-bronze, tungsten-nickel-iron, tungsten-matrix, tungsten-nickel-iron, tungsten-tin-iron-nickel, tungsten-tin-bismuth, tungsten-tin-iron, and tungsten polymers), bismuth, or tin (WFGA 2001). It should be noted, however, that non-lead shot is not currently available for all gauges and pellet sizes, particularly smaller shot sizes (#7½ and #8) which are popular for hunting upland game birds (WFGA 2001).

The use of non-lead shot for hunting upland game is mandated on a variety of federal and state lands, and non-lead shot is used by upland hunters across at least 1.33 million acres nationwide (WFGA 2001). For example, a number of individual National Wildlife Refuges require the use of non-lead shot, as do a number of states such as South Dakota, Wisconsin, and Maine.

The performance of non-lead shot is also roughly equivalent to that of lead shot. Non-lead shot, particularly steel, is lighter than lead and thus has reduced velocity at greater distances, whereas bismuth shot has a density almost equivalent to that of lead. Tungsten alloy shot of several compositions is superior to lead and steel shot, and can be used in double barreled shotguns and older steel barreled shotguns which would be damaged by the higher muzzle pressures created by steel shot. Tungsten alloy shot shells are currently more expensive (\$2.20-3.50 per cartridge) than either lead (\$0.25-0.75 per cartridge) or steel shot (\$0.40-\$0.60 per cartridge).

After the federal ban on lead shot for hunting waterfowl, there were hunter complaints about the effects of non-lead shot on shotgun barrels. Older shotguns not designed for steel shot have a risk of damage to the barrels due to increased pressure of the hard steel shot which may cause “ring-bulge” deformation of the barrel at the choke of older fixed choke shotguns. Double barrel shotguns are also susceptible to barrel damage with steel shot. “Hevi-shot”® , composed of tungsten, nickel, and iron will not damage barrels of older shotguns, although it is considerably more expensive than steel shot. All modern single barreled shotguns manufactured after 1990 use interchangeable choke tubes designed for steel and other non-lead shot, and will not be damaged by any non-lead shot. The USFWS certifies and approves non-lead shot for use in waterfowl hunting (USFWS 2010). The USFWS has currently approved 12 non-lead shot types. A full list can be found at <http://www.fws.gov/migratorybirds/CurrentBirdIssues/nontoxic.htm>.

Mandating the use of non-lead ammunition for hunting would impose some additional costs on some in the hunting community. However, the incremental cost of alternative

ammunition is typically a tiny fraction of the total that hunters spend on their sport. According to the federal government, the average big game hunter in California spends just over \$800 per hunting trip; of which approximately \$173 dollars is spent on all “hunting equipment” with bullets representing a fraction of that cost (USDOJ/DOC 2003). Likewise the cost of shot is a small portion of annual waterfowl or game bird hunting expenses (Scheuhammer and Norris 1995). The Minnesota Department of Natural Resources reports that effective non-lead alternatives to lead shot are now available at costs comparable to lead (Tranel and Kimmel 2009). The price of non-lead ammunition has continued to drop over time as demand has risen. As demand continues to increase and subsequent production costs fall, non-lead bullets and shot will likely become less expensive. On a larger scale, the costs to purchase non-lead ammunition would likely be more than offset by eliminating the societal costs involved in cleaning up and managing lead wastes from lead ammunition.

## **VII. EXISTING FEDERAL AND STATE REGULATIONS**

While TSCA requires the EPA to consider whether actions undertaken under other federal laws adequately address the risk of unreasonable injury in promulgating a rule, this petition presents information on existing regulatory efforts in order to demonstrate that regulation of lead used in hunting ammunition is possible, enforceable and effective, and allows continued hunting; and that despite these efforts, widespread use of lead shot and bullets continues, creating an unreasonable risk of injury to the environment. TSCA does not require a showing of population-level impacts from lead poisonings to regulate toxic lead, only that there is an unreasonable risk of injury to the environment.

There are an increasing number of outreach and education programs by state and federal agencies and non-governmental organizations promoting the voluntary use of non-lead ammunition by hunters. While these programs are important, they have not resulted in a widespread switch to non-lead ammunition by hunters and there is no evidence these programs by themselves have significantly reduced lead exposure to wildlife.

In 1991 the USFWS banned the use or possession of lead shot while hunting waterfowl nationwide (50 C.F.R. § 20.21(j)). This regulation was passed as a result of a lawsuit brought by a coalition of environmental groups, filed under the Endangered Species Act, in response to lead poisoning of waterfowl and secondary poisoning of eagles caused by lead shot. Regulations were phased in nationally over a five year period, with additional zones designated as requiring non-lead shot each year. By September 1, 1991, every state was designated as a non-lead shot zone for hunting waterfowl, coots and certain other species (50 C.F.R. 20.108). While the ban on the use of lead shot for hunting waterfowl has reduced the likelihood of poisoning of raptors that prey on or scavenge waterfowl, it does not prevent the poisoning of raptors that feed on animals hunted away from wetlands or those that feed on a range of avian and mammalian prey. Lead ammunition is still permitted for upland hunting of big game, game birds and non-game mammals on non-federal lands by most states. Continued lead poisoning of condors, eagles, and upland game birds, has prompted some additional restrictions on use of lead ammunition in some National Parks, National Wildlife Refuges, and on public lands in some states. Other than the regulations pertaining to lead shot for waterfowl, the federal government does not regulate the method of take by hunting, deferring to state regulations on federal lands.

A 2006 survey by the Association of Fish and Wildlife Agencies of existing non-lead shot regulations for hunting waterfowl contacted 50 U.S. states, 10 Canadian provinces and 2 Canadian territories (D.J. Case & Associates 2006). The Minnesota Department of Natural Resources also In 2006, 28 states (Alaska, California, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Utah, Washington, and Wyoming) had non-lead shot regulations for dove, crane, rail, snipe, quail, pheasant and/or other game bird and small game hunting on some state-managed lands that go beyond those required by federal law for waterfowl hunting. Some of these restrictions apply to public, but not

private land, and in 7 states the restrictions only apply to mourning dove and/or marsh species such as snipe and rails. In general, the regulations are more widespread for species that overlap in habitat with waterfowl (such as crane, rail, and snipe), and to a lesser degree, doves, and are less restrictive for upland game birds such as grouse, quail and pheasant. Most of these state regulations cover a single or few game bird species in very limited geographic areas (an average of 50,000 acres covered per state). Overall, these regulations cover 1.3 million acres, an extremely small fraction of the public and private lands nationwide where lead ammunition can be used for hunting.

Of the 40 states that allow dove hunting, 16 have some level of non-lead shot requirements specific to dove hunting. In fall of 2008 Wisconsin started requiring dove hunters on public lands to use non-lead shot (Eisele 2008). The Iowa Department of Natural Resources (IDNR) in 2011 approved the first mourning dove hunting season in Iowa since 1918. IDNR prohibited the use of lead ammunition for dove hunting anywhere in the state of Iowa, based largely on the concern that since much of the dove hunting occurs over a small area, allowing lead shot would increase the likelihood of concentrations of toxic lead.

There have only been a few state efforts to restrict use of lead ammunition within the range of special-status species, such as the California condor, spectacled eider and other water birds:

#### *Alaska*

Lead exposure to the threatened spectacled eider and other water birds led to regulations in Alaska in 2007 that prohibit use of lead shot “T” size and smaller for hunting small game, furbearers, and unclassified game in the Yukon-Kuskokwim Delta.

#### *California*

The Ridley-Tree Condor Preservation Act was signed into law in California in 2007, effective July 1, 2008, requiring hunters to use non-lead ammunition for hunting big game (such as deer, elk, pigs, and bighorn sheep) and shooting coyotes within the condor range, which encompasses all or portions of 13 central and southern California counties and seven deer-hunting zones. The California Fish and Game Commission approved additional regulations in 2007 expanding the non-lead requirements to hunting of non-game mammals and birds and prohibiting the use of lead .22-caliber and smaller-rimfire cartridges for non-game hunting in the condor range. In February 2010, California state Assembly member Pedro Nava proposed legislation to ban the use of lead shot in California’s 627,000 acre network of State Wildlife Areas – this legislation passed the state Assembly but was rejected by the Senate in 2010.

#### *National Parks*

In March 2009 the National Park Service announced that it would begin to develop regulations to eliminate the use of lead ammunition in all National Parks by the end of 2010, but has yet to initiate any rulemaking. Grand Teton National Park and National Elk Refuge in Wyoming asked hunters to voluntarily switch to non-lead bullets beginning in fall of 2009.

### *International*

Restrictions on lead ammunition in other countries can inform regulations in the United States. As part of the International Update Report on Lead Poisoning in Waterbirds in 2000, 74 of 137 responding countries had implemented regulations on the use of lead shot, and 37 more countries indicated lead shot legislation was being prepared (Beintema 2001). Restrictions range from voluntary measures to partial bans applied to certain species and areas, to outright statutory bans for all water bird hunting. Use of lead shot to hunt any water bird species is banned outright in Canada, Denmark, Finland, Norway and Switzerland (Beintema 2001). Due to extensive lead poisoning of eagles, in 2001 the Ministry of the Environment in Japan mandated use of non-lead rifle bullets or shotgun slugs for hunting on the island of Hokkaido, Japan (Saito 2009). Canadian national regulation in 1999 prohibited the use of lead shot for hunting all migratory birds anywhere in Canada, exempting upland species such as American woodcock, mourning doves, and rock doves (Scheuhammer 2009).

Avery and Watson (2009b) summarized international lead ammunition legislation, noting that 29 countries have implemented voluntary or legislative restrictions on the use of lead ammunition. The types of bans varied widely and ranged from partial, voluntary restrictions of the use of lead shot to a total ban on the use and import of lead ammunition. Two countries have banned all forms of lead ammunition. Six countries have a partial ban on the use of lead bullets in addition to full bans on lead shot. Four countries have banned the use of lead shot for all hunting. Fourteen countries and some Australian territories have banned the use of lead shot in wetlands or for waterfowl hunting. Two countries have voluntary or recommended restrictions in place. Eleven countries and some Australian territories have a partial ban on lead shot. Seven countries have implemented increasingly strict regulations on lead ammunition over time.

#### **A. Effectiveness of Lead Ammunition Regulations**

Restrictions on the use of lead shot or bullets for hunting have been remarkably effective in significantly reducing lead exposure to wildlife.

Prior to restrictions on using lead shot for hunting waterfowl, it was estimated that from 1.6 to 3.9 million waterfowl died each year in North America from lead poisoning (Bellrose 1959; Feierabend 1983). Within five to six years following the 1991 nationwide ban on use of lead shot for hunting waterfowl, a large-scale study conducted in the Mississippi flyway demonstrated dramatic reductions in the ingestion of lead shot (Anderson et al. 2000). Of the gizzards containing ingested pellets, 68% of mallards, 45% of ring-necked ducks, 44% of scaup, and 71% of canvasbacks contained only non-lead shot. Anderson et al. (2000) estimated that lead poisoning of mallards was reduced by 64% in the Mississippi flyway. Another approach to assessing exposure to lead shot involving a threshold concentration of 0.2 ppm in blood demonstrated a 44% reduction in lead exposure of black ducks from Tennessee by comparing exposure prevalence in 1986 through 1988 to that in 1997 through 1999 after the ban in lead shot for hunting waterfowl (Friend 1985; Samuel and Bowers 2000). An estimated 1.4 million ducks of



the North American fall continental flight were spared from fatal lead poisoning by the 1991 waterfowl regulations (Anderson et al. 2000). Samuel and Bowers (2000) suggest that conversion to non-lead shot conservatively reduced lead exposure in waterfowl by 50%. Similarly, in Canada, substantial decreases (52% to 90%, depending on species and location) in mean bone lead concentrations in hatch-year ducklings have occurred since non-lead shot regulations were established (Stevenson et al. 2005).

The U.S. Fish and Wildlife Service provided data on blood lead levels detected in California condors sampled in California during calendar year 2008 to the California Department of Fish and Game. CDFG concluded that this preliminary information, representing the initial year after adoption of the regulation to prohibit lead ammunition in the condor range in California, is not systematically collected in a manner to evaluate the effectiveness of the lead ammunition regulations because the sources of lead in the sampled condors are unknown, relationships of sampled condors to hunting activity are unknown, and as it relates to the regulations in place that prohibit lead projectiles in condor range, the condor feeding habits for this period of time are also unknown (CDFG 2009). Notwithstanding the preliminary nature of the data and lack of knowledge regarding direct causation, blood lead levels of condors as reported were lower during the second half of 2008 (after the regulations went into effect) compared to the first half of 2008. During the period January-June 2008, 59% of condors sampled had blood lead levels that were considered above background (>10 micrograms/deciliter) levels; 45% of condors exhibited blood lead levels above background levels during July-December 2008 (CDFG 2009).

Blood lead levels were subsequently evaluated for 90 condors in California in 2009 (42 in southern California and 48 in central California). During the period January-June 2009, 60% of condors sampled had blood lead levels that were considered above background (>10 micrograms/deciliter) levels; 54% of condors exhibited blood lead levels above background levels during July-December 2009 (CDFG 2010). CDFG concluded that it is too soon to tell whether the ban on lead ammunition for big game and nongame hunting has significantly reduced the frequency and level of lead exposure in condors, and that the data are not yet adequate for in-depth or meaningful comparison or analysis. Factors to consider that can influence blood lead exposure of condors include time in the wild, long range movements, food sources, foraging habits, and exposure to hunting activities during the sampling period. CDFG is initiating a three-year research project to comprehensively address the effectiveness of the California regulations.

Researchers at the University of California, Davis concluded from the results of a more focused study that the 2008 lead-ammunition ban in the California condor range reduced lead exposure in two avian sentinel species, golden eagles and turkey vultures (Kelly et al. 2011). This study assessed the effectiveness of the California regulations in decreasing blood lead concentration in golden eagles and turkey vultures within the condor range in California, comparing blood lead concentration in eagles and vultures prior to the lead ammunition ban and one year following implementation of the ban. Lead exposure in both golden eagles and turkey vultures declined significantly post-ban. Their findings provide evidence that hunter compliance with lead ammunition regulations was sufficient

to reduce lead exposure in predatory and scavenging birds at their study sites (Kelly et al. 2011).

## VIII. DESCRIPTION OF FEDERAL REGULATIONS REQUESTED

The petitioners formally request that the EPA:

- 1) evaluate the risk of injury to the environment, human health and wildlife from lead bullets and shotgun pellets, used in hunting and shooting sports, which have the potential to cause harmful lead exposure; and
- 2) initiate a proceeding for the issuance of a rulemaking under Section 6(a) of TSCA to adequately protect against such risks (15 U.S.C. § 2620(a); 15 U.S.C. § 2605(a)(2)(A)(i)).

This petition sets forth facts presenting a reasonable basis to conclude that such a rulemaking is necessary to protect wildlife from the ongoing unreasonable risk of injury to health and the environment caused by the use of lead bullets and shot. TSCA grants the EPA the broad authority to regulate chemical substances that “present an unreasonable risk of injury to health or the environment” 15 U.S.C. § 2601. TSCA also mandates that the EPA must regulate chemical substances where there is a “reasonable basis to conclude” that such substances “present an unreasonable risk of injury to health and or the environment” (15 U.S.C. § 2605(a)). The EPA may regulate the manufacture, processing, distribution, use or disposal of such chemical substances. Specific control mechanisms include: prohibitions on an entire or certain use of a chemical substance; limitations on allowable concentration levels; labeling or recordkeeping requirements; and obligations to issue notice of risks of injury. (15 U.S.C. § 2605(a)). Regulations may be achieved through a range of alternatives, up to and including the EPA prohibiting the manufacture, processing, or distribution in commerce of a chemical substance for a particular use (15 U.S.C. § 2605(a)(2)(A)(i)).

Although petitioners advocate for a complete ban on bullets and shot containing lead for use in hunting and shooting sports, with specific exceptions for military and law enforcement uses, with this petition, petitioners request that the EPA evaluate and consider a range of alternatives for rulemaking or revision of rules governing toxic substances, one of which may or may not be a complete ban, to eliminate the potential for harmful lead exposure to wildlife and humans.

## **IX. CONCLUSION**

Section 6 of TSCA requires only that the EPA find that there is “a reasonable basis to conclude” that “the manufacture, processing, distribution in commerce, use, or disposal of” a substance presents an unreasonable risk to the environment or human health in order for the agency to take action. The data presented in this petition provides a reasonable basis to conclude that the risk is such that lead bullets and shot used in hunting and shooting sports should be regulated under TSCA to protect against unreasonable risk of injury to the environment.

This petition has set forth the facts establishing the indisputable toxicity of spent lead bullets and shotgun pellets from hunting and shooting activities to wildlife and to humans. The scientific literature on the sources, quantities, and pathways of exposure of lead in the environment from hunting and shooting sports is comprehensive and conclusive, as is information on the toxic effects and health risk of lead ammunition on wildlife and humans. The banning of lead shot for hunting waterfowl has greatly reduced the massive former mortalities of waterfowl and correspondingly reduced lead consumption by predators and scavengers of waterfowl, such as bald eagles, as well as humans. However, other uses of lead ammunition have continued unabated, causing unnecessary widespread incidental mortality of many bird and mammal species.

Lead-based bullets fragment on impact, distributing toxic lead particles widely throughout carcasses, and making it impossible for scavenging animals or humans to avoid ingesting lead along with meat. Normal butchering processes do not remove this lead. This health risk potentially affects large numbers of people, particularly hunters and their families and in areas where wild game is a significant part of the diet. Lead has been shown to affect adults and children at far lower concentrations in body tissues than formerly thought, and at lower concentrations than current regulations acknowledge.

Many species of wildlife ingest spent lead shot pellets, while others ingest lead fragments from the carcasses and gut piles of shot animals on which they feed. More than 130 species of wildlife are affected by lead from these sources, and in some species thousands or tens of thousands of individuals die from lead ingestion every year in North America. For most species there has been no assessment of the effect of lead-caused mortality on population levels. However, population level effects have been shown in well-studied species such as the California condor, bald eagle, trumpeter swan, sandhill crane and spectacled eider.

The widespread poisoning of many species of wildlife requires a response from the EPA to regulate lead ammunition. This petition presents strong evidence that lead shot and bullets pose an unreasonable risk to health and the environment and that this risk cannot be prevented through action under other federal laws. In evaluating unreasonable risk the EPA must consider: a) the effects of the chemical on health and the magnitude of human exposure; b) the effects of the chemical on the environment and the magnitude of environmental exposure; c) the benefits of the chemical for various uses and the ability of substitutes for such uses; and d) the reasonably ascertainable economic consequences of

the rule, after consideration of the effect on the national economy, small business, technological innovation, the environment, and public health (15 U.S.C. § 2605(c)(1)). Regulation under section 2605 of the Toxic Substances Control Act requires only “a reasonable basis to conclude” that a risk is unreasonable. Scientific theories, projections of trends from currently available data, modeling using reasonable assumptions, and extrapolations from limited data may help to establish risk (H.R. Rep. No. 1341, 94<sup>th</sup> Cong., 2d Sess. 32 (1976)). The data presented in the petition supports the conclusion that the risk is such that lead shot and bullets should be regulated under the Act. The recent granting of a Section 21 petition to ban lead wheel-balancing weights is further evidence that the EPA is aware of the environmental hazards of lead. This petition demonstrates that commercially available non-lead alternatives to lead ammunition are or can be made available to replace toxic lead ammunition currently on the market.

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