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Lead shot concentration in soil at the Overton Wildlife Management Area, Nevada

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Lead Shot Concentration in Soil
at the
Overton Wildlife Management Area, Nevada

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Abstract

During the spring of 1998, soil samples were collected from two areas at the Overton Wildlife Management Area (OWMA), located in the Moapa Valley of Clark County, Nevada. Lead shot has been banned for the hunting of waterfowl since 1986 but is still legal for upland game hunting. Both types of hunting occur at OWMA. One area sampled is a cultivated field and serves primarily as a dove hunting area. The other area is primarily a waterfowl hunting area and is flooded during the waterfowl-hunting season. Lead shot was recovered from 83% of the samples from the dove hunting area, and the estimated concentration was 741,557 pellets per hectare. In the waterfowl hunting area, lead shot was recovered from 13.9% of the samples, and the estimated concentration was 73,231 pellets per hectare. Comparison was made to studies from 14 areas around the world, and OWMA ranked fifth highest in lead shot soil concentrations. The estimated concentrations found here approach or supersede those done prior to the ban of lead in 1986. The years of the other studies ranged from 1959 to 1992. Although lead shot has been banned for use hunting waterfowl, it is still available and continuously being added to the area. This situation permits the availability and not the mitigation of lead shot for ingestion by wildlife.

Acknowledgements

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Introduction

Lead's toxicity is one of the oldest occupational and environmental diseases in the world. Documented use of lead dates back to about 3500 BC and the Romans reportedly produced an average of 60,000 tons of lead per year for 400 years (Lin-Fu, 1985). There are recorded observations of lead poisoning in second century BC Greece, by the poet/physician, Nicander, and in the first century AD, by the physician/pharmacologist, Dioscorides (Lin-Fu, 1985). Even with these early observations and the knowledge gained through the centuries, the Occupational Safety and Health Administration (OSHA) did not have standards for lead until 1979. These standards are still subject to review, court challenges, and OSHA administrative changes (Cheremisinoff & Cheremisinoff, 1993).

Lead's toxicity is not exclusive to humans; reports of anthropogenic contaminants affecting wildlife emerged during the industrial revolution in the 1850s. These reports included arsenic and lead ingestion and toxicity due to smokestack emissions. Among these reports are the deaths of fallow deer from arsenic emissions at a silver foundry in Germany (Hoffman, 1995). Another involves a large die-off of birds and mammals due to hydrogen sulfide fumes near a Texas oil field (Hoffman, 1995). As early as 1874, lead shot ingestion was recognized as a source of mortality of waterfowl and ring-necked pheasants in Texas and North Carolina (Hoffman, 1995).

This study, conducted at the Overton Wildlife Management Area in southern Nevada, determined and compared lead shot densities at two different sites located in the management area. One site is primarily a waterfowl hunting area, where lead shot has been banned since 1986, and the other site is primarily a dove hunting area where lead shot is still legal.

Uses of Lead

Lead's properties, such as resistance to corrosion and flexibility, make it practical for many applications and a common material used by humans. Early uses of lead included pipes for plumbing and glaze on cooking and storage utensils. The use of lead pipes as water conduits dates from prehistoric times and continues today because it is resistant to freeze-thaw cycles (Nriagu, 1985). Some of lead's other useful properties are softness, high density, low melting point, ability to block radiation, readiness to form alloys and chemical compounds, and ease of recycling (Toxic Chemicals in Atlantic Canada-Lead, 1996). Some current uses of lead are for batteries, cable sheathing, construction, glass and paints, protective shielding from various forms of radiation, lead sinkers and weights, and ammunition. Lead is indispensable for starter, storage, and propulsion batteries, and current research and development efforts are directed toward improving lead battery performance rather than finding other suitable materials (Dammert & Chhabra, 1990). However, weight and toxicity are motivating the replacement of lead pipes by plastics, copper, galvanized steel, brass, and aluminum. The use of lead as an anti-knock additive in gasoline and lead pigments in paint, except for paints used for marine purposes, has been practically banned in industrialized countries. Furthermore, substitution by other materials, such as plastics for cable sheathing, has decreased lead use whenever possible if there are environmental concerns (Dammert & Chhabra, 1990).

Lead in the Environment

Lead is found in the environment as a component of various minerals such as galena, cerussite, and anglesite. These minerals are economically important sources of lead (Scheuhammer & Norris, 1995). Lead has an average concentration in the earth's crust of 1.6 g per 100 kg of soil (Pain, 1995). Natural processes such as the weathering of rocks, igneous activity, and natural radioactive decay release small amounts of lead into the environment. Noncontaminated soils contain estimated lead concentrations of about 10-40 μg/g (Scheuhammer & Norris, 1995). Anthropogenic lead emissions have resulted in concentrations in the environment of a higher amount than natural lead concentration estimations (Pain, 1995).

Modern lifestyles depend on lead, but life does not. Unlike iron, zinc, copper, and other metals vital to human physiology, lead has no known function in the human body (Lin-Fu, 1985). An observation that emerged from the Second U.S. National Health and Nutrition Examination Survey, conducted between 1976 and 1980, is that the United States' usage of lead as an anti-knock additive in gasoline declined from 53,000 tons per quarter to 24,000 tons per quarter. Accompanying this reduction of lead use was a drop of the mean blood lead level of the population from 14.6 μg/dl to 9.2 μg/dl. These findings suggest that environmental lead pollution from gasoline and its impacts are potentially within some control (Lin-Fu, 1985).

Potential Hazards of Lead

Lead is a nonspecific toxicant that inhibits the activities of many enzymes required by biological systems. The most widely studied effects of lead on animals are those of the hematological system, brain and nervous system, learning and behavior, and reproduction and survival (Pain, 1995). Experimental studies of the effects of lead on animals form a large part of our understanding of the physiological and biological activity but may not be adequate predictors of its effects in the wild. Under natural conditions there is a wide range of exposures to compounds that may act antagonistically or synergistically (Pain, 1995).

The most frequently observed effects of lead on wild animals are those in wild birds.

Knowledge that waterfowl ingest lead shotgun pellets as food items or grit was gained in the late 1800s (Scheuhammmer & Norris, 1996). These lead pellets lodge in the gizzard where the grinding action and the acidic environment promote the release of ionic lead into the bloodstream (See Figure 4 in Appendix A). Lead poisoning primarily exerts its effects upon the nervous system, kidneys, and circulatory system. These insults on tissues result in biochemical, physiological, and behavioral impairments (Scheuhammer & Norris, 1996). Manifestations of lead poisoning in waterfowl are green stained diarrhea, neuromuscular disorders, inability to fly (wing drop) or stand, starvation, weakness, and finally death (Guitart et al., 1994). Lead pellets remain in the gizzard for a 20 day period before they pass through or the bird dies (Bellrose, 1976). Conservative estimates are that 2 to 3 percent of fall and winter waterfowl population become casualties of lead shot poisoning (Bellrose, 1976).

The risk of lead shot ingestion does not limit itself to waterfowl. Many other avian species frequent the same habitat as waterfowl and any environment where lead shot exists can potentially result with ingestion and lead poisoning. Upland game bird hunting areas, such as those for doves in the United States, are potential spots for lead shot ingestion by other species. Mourning doves sampled in Tennessee, Maryland and New Mexico showed 1 to 6.5 percent with ingested lead shot or high tissue concentrations of lead (Scheuhammer & Norris, 1996).

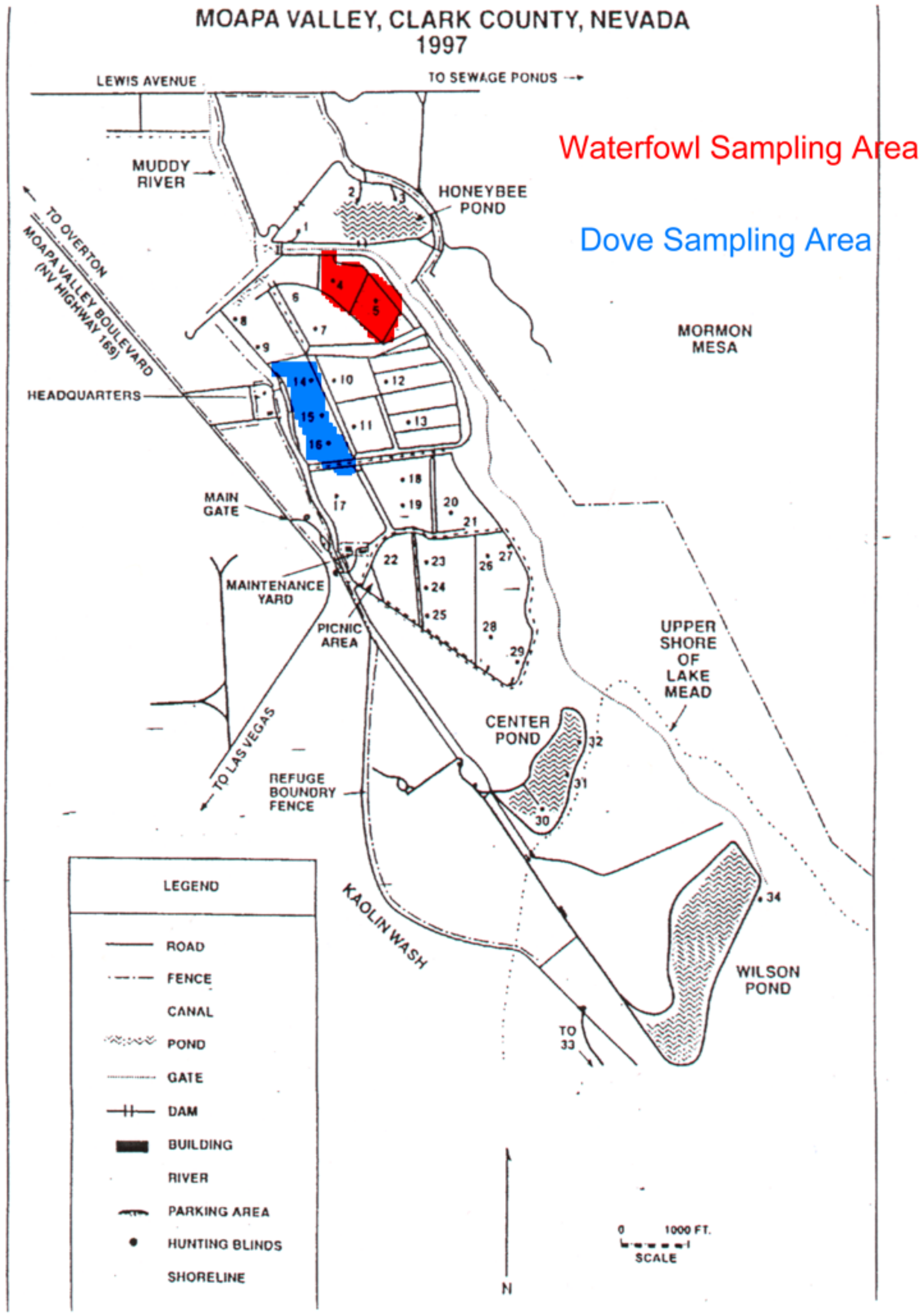
Furthermore, consumption of waterfowl and upland game birds harvested using lead shot are potential sources of lead exposure in humans. In *A Review of the Environmental Impacts of Lead Shotshell Ammunition and Lead Fishing Weights in Canada*, published in 1995, Scheuhammer and Norris point out three routes of lead exposure in humans from the consumption of wild game. The first route is ingestion of lead exposed and poisoned animals that have higher than normal concentrations of lead. The second route is the ingestion of tissues with lead flakes from passage of lead shot through the tissue. The third route is through ingestion of lead shot pellets that have not been removed from the animals before consumption. There have been reported incidents of health effects in humans after ingestion of lead shot pellets, especially those that had pellets lodged in their appendix. One case in a Danish study reported 35 lead pellets in one appendix and a Canadian report from a Newfoundland hospital found from one to over 200 pellets in the appendices of 62 patients (Scheuhammer & Norris, 1995).

Purpose of Study

There have been several studies about the concentration of lead shot in the environment and the ingestion of these pellets by waterfowl and doves. Among the earlier studies found cited in the literature on this subject are Bellrose's (1959) about waterfowl and Lewis and Legler's (1968) about mourning doves. In southern Nevada there is a wildlife management area where upland game birds (dove, quail, etc.) and waterfowl are hunted within its confines. This is the Overton Wildlife Management Area (OWMA) located in the Moapa Valley of Clark County Nevada. Hunting waterfowl with lead shot has been banned at this site since 1986, but using lead shot to harvest other game birds and animals is still legal. The potential exists for substantial quantities of lead shot in this area. One area located near blinds 14, 15, and 16 is cultivated with grains to supply feed for birds, consequently creating a prime dove hunting area (See map, Fig. 1).

Figure 1

OVERTON WILDLIFE MANAGEMENT AREA, NEVADA



Soil samples were taken from these fields to enable us to make an estimate of lead shot concentration in these areas. In addition, soil samples were taken from the areas near blinds 4 and 5, prime waterfowl hunting areas, and this concentration was compared to the dove hunting area. Since lead is banned for the hunting of waterfowl, I expected that the densities of lead shot would be higher in the dove hunting area than in the waterfowl hunting area.

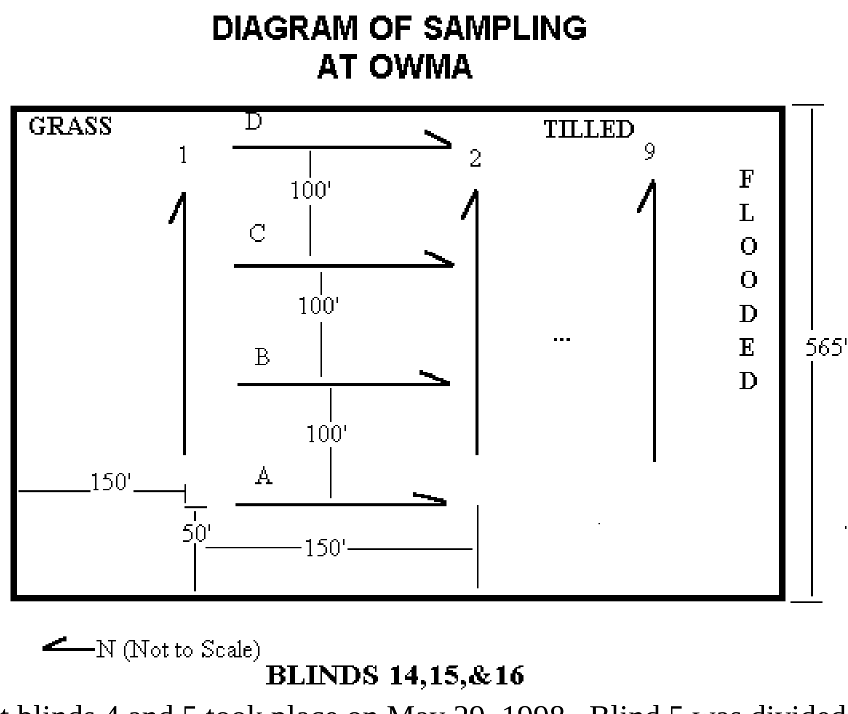
Materials and Methods

We conducted the study to determine the amount of lead shot in two areas of the OWMA. This wildlife management area has been a hunting ground for upland game birds and waterfowl since 1950, and has the potential for a high concentration of lead shot. Hunting waterfowl with lead shot has been banned in some areas of the U.S., including OWMA, since 1986 and in all areas of the U.S. since 1991. However, hunting other game birds and animals with lead shot is still legal.

An equal number of samples were taken from two different areas for comparison of the amount of lead pellets found. One area near blinds 14, 15, and 16 is a large field that is tilled, planted, and irrigated and serves primarily as a dove hunting area. The other area contains blinds 4 and 5 and is primarily a waterfowl hunting area (See Figure 1). This area is flooded prior to the hunting season to provide waterfowl habitat and drained immediately following the season. Thirty-six soil samples, 0.5 ft. x 0.5 ft. x 0.3 ft., were taken from an area surrounding blinds 14, 15, and 16, and a total of 36 samples, of the same size, were taken from blinds 4 and 5 combined. Twenty samples were taken from blind 5 and 16 samples from blind 4. The total surface area sampled in the dove field is 360,000 square feet, which is about 3.34 hectares (ha). The total surface area sampled at blinds 4 and 5 is 210,00 square feet, which is about 1.95ha.

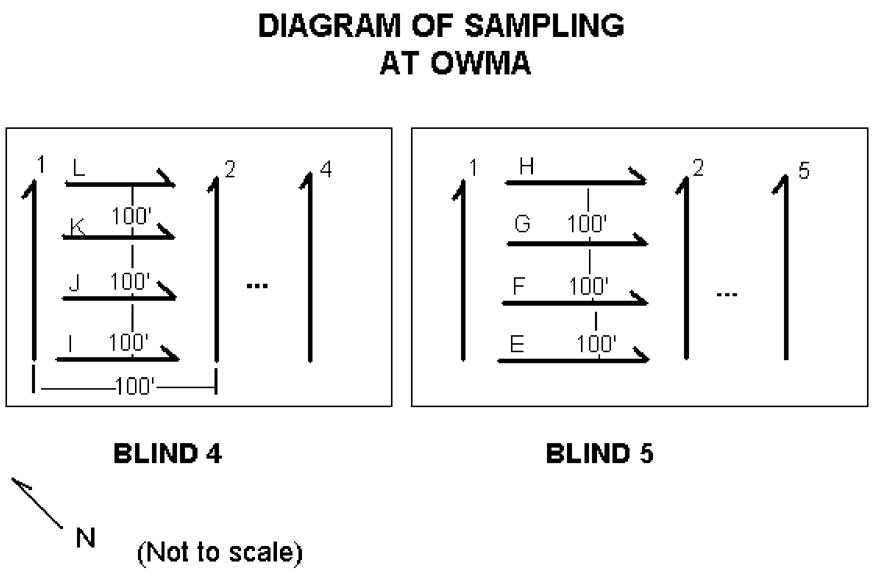
The dove-hunting field was sampled on April 24, 1998, which was two weeks after the spring turkey season. Half of the field was tilled, and the south end was being flooded on the day of sampling. On the east-west axis, the field was divided into four transects, and samples were taken at 100 foot intervals. The north-south axis was divided into nine transects, and samples were taken every 150 feet (Figure 2). From the north end (the left side of diagram) the grass extended south for approximately 500 feet, and the rest of the field was tilled. These samples were reasonably dry, except that eight of them from the grassy area contained moisture. Samples were labeled, starting with A1 in the northwest corner and increasing as we move south to A2, A3. Moving east, the next row begins with B1 on the north end and continues numbering the same as in row A, with C and D following the same process.

Figure 2



Sampling at blinds 4 and 5 took place on May 29, 1998. Blind 5 was divided by four transects on one axis and five along the other axis. Blind 4 was divided into four transects along each axis. Samples were collected at 100-foot intervals along both axes at these sites. Figure 3 is an illustration of the sampling layout of blinds 4 and 5. This made it possible to compare the 36 samples from the dove hunting area to the 36 samples from the waterfowl hunting area. These areas were muddy, and all of the samples were wet. Labeling was done in a similar manner to that used at blinds 14, 15, and 16.

Figure 3



Samples were collected using a narrow shovel that is 6 inches wide. It was marked to indicate a depth of 0.3 feet (3.6 inches / 9.1 centimeters). A square was cut into the soil to the 0.3 foot depth, then scooped out with the shovel, providing a sample size of approximately 0.075 cubic feet (0.5 ft. x 0.5 ft. x 0.3 ft.). Each sample was placed in a labeled plastic bag and taken back to the laboratory at the University of Nevada, Las Vegas for processing.

Each sample was sifted through a Hubbard soil sieve, using mesh sizes 5, 120, and 230. The smallest shot sizes common for doves are number 8 and 9; these shots are 2mm and 2.25mm in diameter respectively. The mesh sizes 120 and 230 have sieve openings of 125 μm and 63 μm respectively. Mesh size 5 was used to remove larger material. The samples from the dove area were sifted three times. They were sifted twice because of the difficulty in distinguishing lead shot in the soil. The third sifting was done by rinsing with water. Since most shot was found after sieving with water, and the samples from blind 4 and 5 were moist, they were first dissolved in five-gallon buckets of water and then sieved using water through mesh sizes 120 and 230. Each sample bag from all sites was rinsed out with water and sieved. We identified pellets found as lead or steel by using a magnet. We then checked resistance to crushing by smashing them with a hammer.

Pellet densities were estimated by a method similar to that described by Rocke, Brand, and Mensik, 1997, using the mean number of pellets found and the surface area of each sample. The mean number of pellets found per sample area was extrapolated to the total surface area sampled to estimate pellet concentration. Concentration measures for this study are reported as pellets per hectare (ha).

The surface area of each sample was .25 square feet (0.5 ft. x 0.5 ft.). Estimation of shot concentration at blinds 14, 15, and 16 was calculated by taking the average number of lead pellets per sample and multiplying it by four to obtain the number of pellets per square foot. The total surface area sampled at blinds 14, 15, and 16 is 360,000 square feet. A conversion of the sampled surface area to hectares was done by using 43,560 square feet per acre and .4046856 hectares per acre giving a surface area for sampling at blinds 14, 15, and 16 of approximately 3.34 hectares. Shot concentration for blinds 4 and 5 were conducted using the same procedure as previously described. The total surface area sampled at blinds 4 and 5 was 210,000 square feet or approximately 1.95 hectares.

Results

In the area of blinds 14, 15, and 16, a total of 62 lead and 1 steel pellet was found. Thirty of the 36 samples contained lead pellets (83%). The shot density was calculated as 62 pellets/36 samples = 1.72 pellets/sample. This result times 4 equals 6.88 pellets per square foot, and multiplying by 360,000 estimates 2,476,800 pellets in the area sampled at blinds 14, 15, and 16. Pellets per hectare for blinds 14, 15, and 16 is then calculated as 2,476,800 pellets / 3.34 ha = 741,557 pellets / ha.

Blinds 4 and 5 had a total of 6 lead pellets in 5 samples of the 36 (13.9%). Eight steel pellets were also found in 6 samples of which only 1 sample contained lead and steel.
The average number of pellets was 6 pellets / 36 samples = .17 pellets / sample and this result multiplied times four equals .68 pellets per square foot. The estimate of the total number of pellets from the area sampled at blinds 4 and 5 was calculated as .68 pellets per square foot times 210,000 square feet equals 142,800 pellets. This figure divided by 1.95 hectares results in a calculation of 73,231 pellets / ha for blinds 4 and 5.

Discussion

The amount of lead pellets found and the densities concur with the expected higher concentration at blinds 14, 15, and 16. Because this field is cultivated, it is difficult to make an estimate of pellets available for ingestion at any time. Previous investigations indicated that discing or plowing a field soon after hunting season can reduce the quantity of lead pellets available in the top 2 inches of soil surface as much as 78 % (Lewis & Legler, 1968). The dove field near blinds 23, 24, and 25 (not part of this study) will be plowed after two weeks of the dove season. Plowing of this field could help reduce the availability of lead pellets available for ingestion by wildlife.

The lower shot density at blinds 4 and 5, compared to blinds 14, 15, and 16, suggest that the banning of lead shot for waterfowl hunting has been a potential factor in reducing lead shots presence in the soil. However, since this area has been hunted since 1950 the lead shot had to migrate somewhere. These blinds are flooded and drained every year. Lead pellets do not break down unless the environment is acidic. The OWMA soils are alkaline. Two things to possibly study in the future would be to sample at greater depths and take samples along the drainage path. Taking soil samples at greater depths may explain that the downward migration of lead in soils is eliminating it from potential ingestion by wildlife. Sampling of the drainage area may explain if lead pellets are being transported from the area. Figure 5, in Appendix A, shows where the lead pellets were found in the sampling areas. The lead pellets found in blinds 4 and 5 could possibly be deposited from hunting in adjacent dove fields.

Estimates of the shot concentrations at OWMA suggest that lead is available to waterfowl and upland game birds that inhabit and pass through the area. The findings reported herein are higher than most areas reported in the literature but not as high as those reported at Willows, California (Rocke et al., 1997) and Camargue, France (Pain, 1991). Table 1, in Appendix A, lists the pellets per hectare of several studies, and Figure 6, in Appendix A, shows a graph of the results for comparison. Comparing these studies is difficult because the depths of sampling vary from 1.3 cm (Best, Garrison, & Schmitt, 1992) to 20 cm (Pain, 1991). There is also the factor of differences in habitat, such as the geology, vegetation, and the amounts of time they are flooded every year. Of the studies listed in Table 1, Illinois, Indiana, and Tennessee are cultivated fields. This study is composed of two different types of habitat with blinds 4 and 5 being semi-marsh, and blinds 14, 15, and 16 being a cultivated field.

Since the amount of lead found at blinds 4 and 5 is several times less than that found at blinds 14, 15, and 16, the banning of lead shot appears to have reduced its presence in this area. This concurs with a statement in the United States Fish and Wildlife Service (USFWS) news release dated March 7, 1995 saying that lead deposition has been substantially reduced in most wetlands since the phasing out of lead shot, beginning in 1986. Another issue is whether nontoxic shot should also be required for the hunting of upland game birds. In 1995, nontoxic shot was required for hunting upland game on selected national wildlife refuges after being successfully implemented on the West Coast in 1991 and in the Southwest during the 1992-93 hunting season. Nontoxic shot is also required on all waterfowl production areas since the 1996-97 hunting season (U. S. Fish and Wildlife Service, 1995).

In order to maintain a healthy population of waterfowl and upland game birds, the reduction of lead shot in the environment is one option that has already shown success. There is an array of complex environmental and physiological factors affecting wildlife populations; among these are hunting, predation, and loss of habitat. The loss of habitat has increased predatory success rates because it requires high concentration of nests in small areas. As much as 40 percent of nesting hens are killed by predators (Qualley, 1997). Reduced habitat makes it easier for predators to find prey concentrated in a small area. Hunting has not been proven a major constituent in population reduction. The harvest of waterfowl and upland game birds is regulated by national and state wildlife departments. Increasing the amount of habitat is a difficult process, with legal and political obstacles. Nontoxic shot has been in use since 1991 for hunting of waterfowl, and hunters are successful with the new shot types. If the goal were to maintain a population for future generations to utilize for recreation, hunting and non-hunting, the expansion of the nontoxic shot regulation for hunting upland game birds would be a small price. A USFWS finding is that deposition of spent lead shot associated with upland game bird hunting is almost five times greater than that associated with waterfowl hunting (Kendall et al., 1996). At OWMA the estimate of shot concentration in the dove field is about 10 times greater than that estimated in the waterfowl area. This suggests that without some mitigation, the lead shot density will become more concentrated.

Several studies have been done on the ingestion of lead shot by upland game birds, especially mourning doves. The ingestion of lead by these species can continue through the food chain. Lead poisoning was evaluated in bald eagles in British Columbia from 1988 to 1991, and the greatest number of lead poisoned birds was received during the months of January to March, when eagles feed heavily on wintering waterfowl (Elliot et al., 1992). Carrington and Mirarchi, did a study of doves they contaminated with lead shot. They said that the locations where doves that were contaminated with lead shot had been killed or scavenged, suggested that these doves were not behaving normally and that the lead contamination was affecting them (Carrington & Mirarchi, 1989). Furthermore, Buerger et al. in 1986 found that ingestion of one lead shot by female doves caused a reduction in hatchability of eggs (Best et al., 1992). Lead shot is not the only factor impinging upon wildlife, but removal of any detrimental factor can only aid their ability to survive. There are several factors that influence lead’s impact of exposure, including number of shot ingested, weather, and diet (Castrale, 1993). All wildlife that are exposed to lead shot will not die or become ill, but since there are satisfactory substitutes for lead, they should be implemented to aid in the survivability of wildlife resources for use by future generations. If there is something that can be done to reduce detrimental affects upon organisms that are natural resources, then that is the prudent decision to make.

The public, hunters and non-hunters, as well as the hunting industry, would benefit if policies were made to maintain a sustainable recreational activity. Data suggests that an increasing number of people are participating in upland game bird hunting; accompanying this increase are decreases in quality habitats and high concentrations of lead shot in these habitats (Kendall et al., 1996). The banning of lead shot for upland game bird hunting would aid in the long-term sustainability of wildlife and the sport.

One aspect of changing the regulations will be the increased cost to hunters for the alternative nontoxic ammunition. I priced 12 gauge shothells of comparable size at a local Wal Mart. This store did not carry exactly the same size in steel and lead shot. The price for a box of Federal steel number 6 shot size was $11.87, while a box of Federal number 7.5 shot size was $4.27. The cost of steel shot is almost 3 times greater than that of lead shot. Although the shot sizes were different, the comparison appears accurate, since shot sizes varied in each category (steel and lead) but did not vary in price.

Another problem with the steel shot is its effect on currently manufactured shotguns. Ninety-five percent of shotguns presently in use will not be damaged by steel shot; however, the other 5 percent may suffer ring bulge, which is strictly cosmetic and does not weaken or alter patterning performance (New rules for lead shot: facts and myths, 1997). This would impact the value of the shotgun for resale. The impact would more likely be upon collector quality shotguns, which are less likely to be used for general hunting purposes.

A more promising nontoxic alternative to lead is the bismuth shot, which is an element that is located next to lead on the periodic table. This shot is manufactured with a technological alliance between the Bismuth Cartridge Company and Winchester Ammunition. Bismuth-tin shot is composed of 97 percent bismuth and 3 percent tin, with a ballistic performance that is very similar to lead (Winchester Ammunition, 1998). Bismuth was approved for hunting of waterfowl by the USFWS in January of 1997. Bismuth is the only nontoxic shot recommended by two of England's top gun makers, Purdey and Sonsand Holland & Holland (Winchester Ammunition, 1998).

Another alternative nontoxic shot is tungsten-iron, which received temporary approval by the USFWS for the 1997-98 and 1998-99 waterfowl hunting seasons. Tungsten-iron shot is manufactured by the Federal Cartridge Company and is composed of 40 percent tungsten and 60 percent iron. There is a problem with the use of tungsten-iron shot in older shotguns. On the Brinnel Scale of hardness, tungsten alloy shot measures 260, while bismuth shot measures 18, and antimony-lead shot measures 12. Tungsten is harder than the other alternatives and significantly harder than the steel used to manufacture shotgun barrels (Winchester Ammunition, 1998). This limits its ability to be used by some hunters.

Conclusion

The OWMA ranks as the fifth highest in the comparison of fourteen areas that were studied for lead shot density. The estimated concentration found here approached or superseded those studies done prior to the ban of lead in 1986. Lead is a nonspecific toxicant that inhibits the activities of many enzymes required by biological systems. Lead poisoning primarily exerts its effects upon the nervous system, kidneys, and circulatory system, which result in biochemical, physiological, and behavioral impairments. The most frequently observed effects of lead on wild animals are those in wild birds following ingestion of lead shot as food or grit. Many migratory birds land and feed at OWMA. During dove season, potentially 50 hunters per day are permitted to hunt at OWMA. If we assume that each hunter shoots at least one box of shotgun shells, and each shell contains about 1.25 ounces of lead; this calculates to just under 2 pounds of lead per hunter per day. That is 100 pounds of lead per day for a month long season. This conservative estimate of the input of lead shot shows that many pellets are available for ingestion by wildlife, and mitigation of lead at OWMA should be considered.

Three alternatives to be considered are the banning of lead, discing or plowing shortly after the hunting season, and phytoremediation. The banning of lead to mitigate lead shot for upland game hunting is done at the federal level in some areas. The USFWS started phasing out lead shot on national wildlife refuges in 1995 and on all refuges and waterfowl production areas for the 1996-97 hunting season. In addition to the USFWS requirements, South Dakota has also required the use of nontoxic shot for upland game hunting on some state lands. On September 1, 1998, the use of nontoxic shot was required in state game production areas, state parks, state recreation areas, state lakeside use areas, and state water access areas (South Dakota Game, Fish, and Parks, 1998). However, a disadvantage to this policy is that the higher cost of nontoxic substitutes potentially reduces the ability of lower socioeconomic hunters to participate. Since there are lotteries to gain access to hunt at OWMA, a possible incentive would be to put hunters that use nontoxic shot into the first pool of hunters to be drawn.

Another alternative would be to disc or plow the dove fields soon after the season, which reduces the availability of lead shot at the surface, as previously mentioned from the study of

Lewis and Legler in 1968. However, if the fields are seasonally disced and plowed for the planting of feed for the birds, the lead shot will likely return to the surface at some time during this cycling.

Lastly, phytoremediation, the technique of using plants to pull metals out of the soil solution and into the plant structure is a process being studied by the United States Army Environmental Center (Phytoremediation of lead in soil, 1997). This alternative is not practical for OWMA if lead shot is continually put into the environment. Also, the lead shot at OWMA is in elemental form, and plants take up the metals that are in solution. Furthermore, the objective is to eliminate the availability of lead shot for ingestion by wildlife, not necessarily remediation of the area.

Lead has been a useful element for many purposes for several thousand years, and its toxicity has been suspected for a few thousand years. When an element is known to be toxic and substitutes are available, the prudent decision is to use the substitute or reduce the potential exposure to that element. The findings of this study indicate that lead shot is potentially available to wildlife at OWMA. It is illogical to have a policy of banning lead shot for the hunting of waterfowl to reduce exposure, and permitting lead shot for hunting upland game in the same area. I recommend that the Nevada Division of Wildlife consider banning lead shot at the Overton Wildlife Management Area.

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