BALD EAGLE LEAD POISONING IN WINTER

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ABSTRACT.—Wildlife rehabilitators across the state of Iowa began gathering lead poisoning information on Bald Eagles (*Haliaeetus leucocephalus*) in January 2004 for this ongoing project. Blood, liver, or bone samples were analyzed for lead levels from 62 of the 82 eagles currently in the database. 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 fifty percent 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. With thousands of Bald Eagles spending the winter in Iowa (up to one fifth of the lower 48 states population), this poisoning mortality could be significant and is preventable. Educational efforts are being directed at encouraging deer hunters to switch from lead to non-toxic (copper) slugs and bullets. *Received 30 May 2008, accepted 4 September 2008.*

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Key Words: Bald Eagles, Iowa, lead poisoning, White-tailed Deer, lead slugs.

LEAD POISONING IN BALD EAGLES has been well documented in eagles brought in for rehabilitation (Kramer and Redig 1997, Franson et al. 2002) and in wild populations (Hermata and Restani 1995, Miller et al. 1998, Wayland and Bollinger 1999). In a review of published data, Sanborn (2002) found the sources of lead poisoning in wildlife overwhelmingly to be spent ammunition and fishing tackle. A unique convergence of events seems to be occurring in Iowa that could have potentially significant consequences for Bald Eagles. Iowa has become a major wintering area for eagles, documented by Christmas Bird Count (National Audubon Society 2002) and Iowa's Midwinter Bald Eagle Survey (Iowa Department of Natural Resources 2007). This influx of eagles to the state occurs during the major hunting seasons. As reducing and controlling the White-tailed Deer numbers in the state has become a priority for the Iowa Department of Natural Resources (IDNR), the number of deer harvested has increased along with new and lengthened seasons for hunting with guns. The increased harvest results in an increased availability of deer carcasses (Nixon et al. 2001). The added seasons for deer harvest with guns provides for carcasses to be available over more of the eagle's wintering cycle then when deer were hunted during a limited part of December.

In the fall of 2004 and winter of 2005 wildlife rehabilitators in Iowa noticed an increase in the number of Bald Eagles admitted for treatment, and most of the increase in cases was associated with lead poisoning or exposure. Wildlife rehabilitators are an excellent source of information and monitoring for wildlife mortality factors (e.g., West Nile virus, avian flu, illegal activities, secondary poisonings). Their work provides a sample of what is happening to wild animals that would cause death without human intervention. The data gathered by Iowa wildlife rehabilitators show an alarming rate of lead poisoning and exposure in Bald Eagles during their wintering cycle in Iowa.

METHODS

Saving Our Avian Resources (SOAR) began collecting Bald Eagle data from other Iowa rehabilitators in 2004. SOAR, MacBride Raptor Project, Orphaned and Injured Wildlife, Inc., Wildlife Care Clinic, Inc., and Blackhawk Wildlife Rehabilitation Project are the main facilities in Iowa working with Bald Eagles. Data recorded included: date admitted or found dead, county where found, eagle's age, facility doing treatment, lead levels (in blood, liver, or bone), full body x-ray results, and end results (released, died, euthanized, permanent captive). Lead levels were determined from liver samples in the cases when the eagle died before blood could be obtained. Data include lead levels from nine liver samples and one bone sample from eagle carcasses found and retrieved from the field by the public or Conservation Officers.

Blood lead levels were determined by laboratory analysis (Antech Diagnostics, Southaven, MS) or on-site analysis using ESA, Inc., LeadCare® system. Blood lead levels higher than 0.1 ppm but lower than 0.2 ppm were considered lead exposure cases. Exposure being defined as the animal has a higher than background level of lead in its system, indicating that it ingested an anthropogenic source of lead. Any blood lead level >0.1 ppm was considered abnormal (P. Redig pers. comm.). Exposure levels are below that at which chelation treatment is begun. Blood lead levels higher than 0.2 ppm were considered poisoning cases and chelation treatment was started if clinical symptoms warranted (Antech Diagnostics). These interpretations of blood lead levels agree with the thresholds for humans (AAP 2005 and CDC 2008). Liver and bone samples were analyzed for lead levels by Iowa State University Diagnostic Laboratory. Lead levels in liver higher than 1 ppm but lower than 6 ppm were considered lead exposure cases. Lead levels in liver greater than 6 ppm were considered lethal poisoning cases. Any liver level ≥1 ppm was considered abnormal. Lead levels in bone between 10 ppm and 20 ppm were considered exposure levels; greater than 20 ppm were considered poisoning levels. Any lead level in bone ≥10 ppm was considered abnormal (Puls 1994). Exposure levels may not cause death by themselves. Poisoning levels can be lethal without treatment. All animals admitted to a rehabilitator are considered a wild fatality; the animal would have died without human intervention. Data were analyzed on a by-month basis to determine timing of most lead poisoning or exposure cases.

Full body x-rays were examined for any remaining evidence of solid lead in eagles' digestive tracts. Trailcams were placed near salvaged, relocated, road-killed deer carcasses from early December to late March to assess use by wildlife. Deer harvest and eagle wintering population data were examined for associations to the number of abnormal lead level cases. Attendees at Iowa's Deer Classic were surveyed for attitudes regarding the impacts of lead on wildlife and human health, and their use of and satisfaction with non-lead ammunition.

RESULTS

Data were gathered on 82 Bald Eagles admitted to Iowa wildlife rehabilitators from 1 January 2004 to 30 April 2008 (Table 1 and Figure 1). Sixty-two of these eagles were tested for lead levels. Thirty-nine of these tests showed poisoning (potentially lethal) levels of lead in blood or liver (≥0.2 ppm in blood and ≥6 ppm in liver). Seven of those tested showed exposure levels of lead (between 0.1 and 0.2 ppm in blood or between 1 ppm and 6 ppm in liver or between 10 ppm and 20 ppm in bone). Abnormal lead levels (any level ≥0.1 ppm in blood or ≥1 ppm in liver or ≥10 ppm in bone) ranged from 37.5% of all eagles admitted (with 62.5% being tested) in 2004 to 70.0% of all eagles admitted (with 90.0% being tested) in 2005. Over the study period, 56% of all eagles admitted to Iowa wildlife rehabilitators had abnormal lead levels. Of the 46 eagles from Iowa with abnormal lead levels, 38 died (82.6%), four are permanent education birds due to secondary

Table 1. Bald Eagles admitted to Iowa wildlife rehabilitators.

Year	Total no. of eagles admitted to Iowa wildlife rehabilitators	No. tested for lead (% of total)	No. showing lead exposure	No. showing lead poisoning (lethal without treatment)	% of total showing abnormal lead levels
2004	8	5 (62.5%)	0	3	37.5%
2005	20	18 (90.0%)	1	13	70.0%
2006	20	11 (55.0%)	2	7	45.0%
2007	23	17 (73.9%)	2	11	56.5%
1 January through 30 April, 2008	11	11 (100.0%)	2	5	63.6%
TOTAL	82	62 (75.6%)	7	39	56.0%

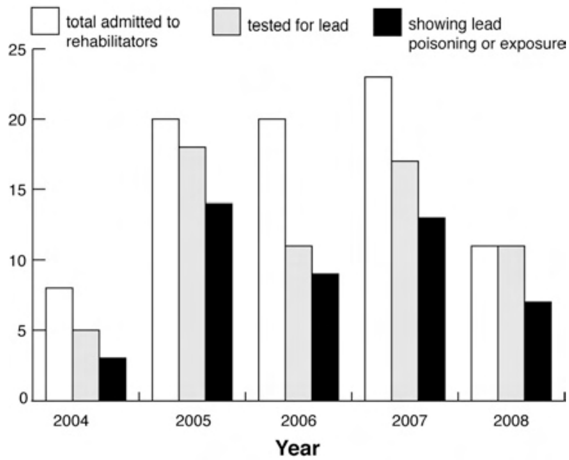


Figure 1. Incidence of abnormal lead levels in Iowa wintering Bald Eagles.

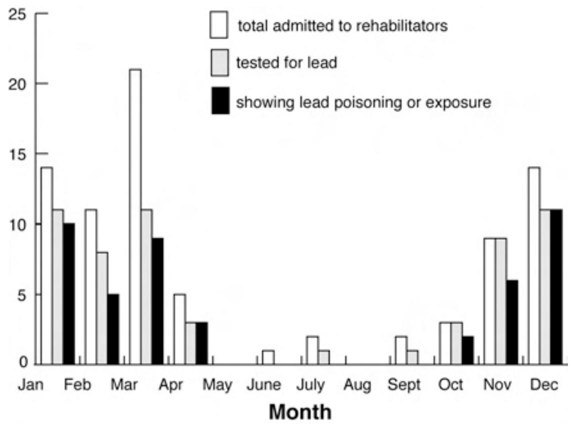


Figure 2. Seasonality of Bald Eagles admitted to Iowa wildlife rehabilitators.

trauma injuries (8.7%), and four were released to the wild (8.7%).

Time-of-year data (Figure 2) revealed a strong relationship of poisoning cases with both the increase in the numbers of eagles as they move into the state during the fall and the start of hunting seasons. Cases increased through the winter (December and January) peak deer harvest months. Poisoning cases showed another spike during early spring (March), as eagles traveled across country away from water sources, during their early spring movement north. This March movement was documented by a peak in the number of eagles observed feeding from carcasses placed near a trailcam. It is likely that more scavenging occurs during this northward migration period and more carcasses would be available to visual scavengers after snow melt. The number of eagles admitted with abnormal lead levels drops to zero in May and no poisoning cases are seen again until October.

Eagles readily feed on deer carcasses, in groups, for several days. A marked increase in eagle use of carcasses was noted the first week in March (Figure 3).

One White-tailed Deer shot with two lead slugs was x-rayed for shrapnel content. There were many remaining lead fragments in the carcass large enough to be lethal to a Bald Eagle (Figure 4).

Whole body x-rays of eagles showed lead shrapnel (Figs. 5a and 5b), shot (Figure 5c), or larger pieces of lead (Figure 5d) in eagle digestive tracts. Fifty-nine eagles were x-rayed, with seven eagles showing lead remaining in digestive tracts. It is very difficult to find the source of lead poisoning remaining

Figure 3. Bald Eagles feeding on deer carcasses in March.

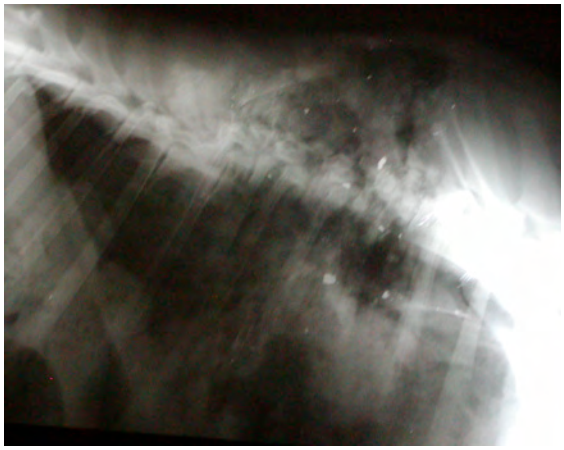


Figure 4. Lead shrapnel in deer shot with two lead slugs.

in the digestive tract of the eagle due to the eagle's very efficient digestive system and the time until the bird is debilitated enough to be caught in the field.

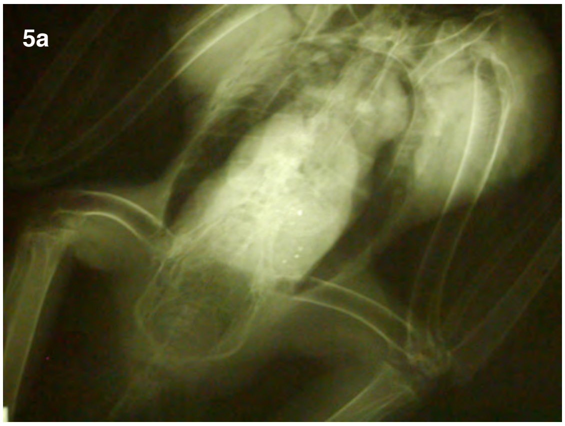
Of the 151 respondents to a Hunter Ammunition Survey, 62.9 % knew that lead fragments in scavenged meals could harm wildlife and 74.2% knew that lead fragments found in game meat could pose a human health risk. Forty-three percent of the respondents had used solid copper slugs or bullets to hunt big game. Of these, 87.7% liked the performance of the copper. A high percentage of respondents, 58.3%, had used non-lead/non-toxic shot for upland game hunting. Of these, 93.2% were satisfied with the results using the lead-free ammunition. When asked "For wildlife and human health reasons, do you think that lead ammunition should be phased out in favor of non-lead/non-toxic alternatives?" 83.4% said yes, 12% said no, and 4.6% said they were unsure.

DISCUSSION

An average of 56% of all Bald Eagles admitted to Iowa wildlife rehabilitators had abnormal lead levels. This is a much higher rate than that reported from other state rehabilitation efforts. The Raptor Center, University of Minnesota averages 25% of eagle patients with abnormal lead levels (The Raptor Center 2008). Raptor Recovery Nebraska averages 20% of eagle patients with abnormal lead levels (B. Finch Raptor Recovery Nebraska, pers. comm.). The amount of effort (percentage of total cases tested for lead) may explain the higher rate of poisoning cases in Iowa as compared to other rehabilitation facilities. These facilities may not test individuals that are admitted with obvious trauma and attribute the cause for admission as the trauma, with the underlying lead levels going undetected. Ten (21.7%) of the eagles with abnormal lead levels in Iowa's data set also suffered from trauma (five gunshot, five impact trauma). The trauma may have occurred due to the lead in the bird's system, which may make it less wary, increase reaction time, and affect vision and nervous system function.

Another explanation for the lower rate of eagle lead exposure or poisoning in other states is that Iowa has become a significant wintering area for a large number of Bald Eagles. There may be fewer eagles in Minnesota and Nebraska during the winter. This is supported by the Iowa Mid-Winter Bald Eagle Survey (IDNR 2007) (Figure 6a) and Christmas Bird Count data (National Audubon Society 2002) (Figure 6b). Therefore, the comparatively high incidence of lead contamination in wintering Bald Eagles from Iowa is a matter of concern.

Eagles are attracted to Iowa by open water in river systems and below reservoir dams. Hundreds of eagles congregate in these fishing spots throughout the winter months. Iowa also has ample scavenging opportunities, as the hunting seasons are ongoing during the time thousands of eagles are wintering in the state. Deer carcasses may be the most available



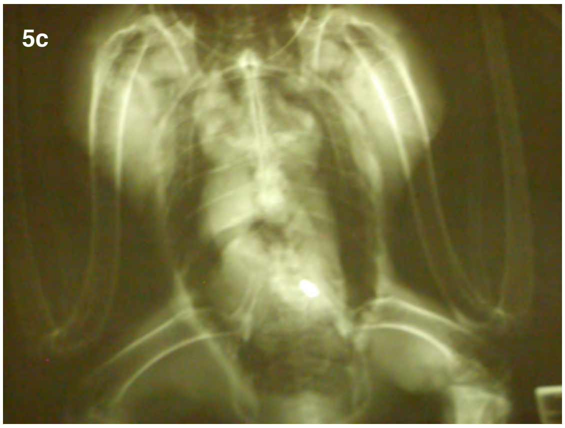


Figure 5a. Lead shrapnel in Bald Eagle digestive tract.

Figure 5b. Lead shrapnel in Bald Eagle digestive tract.

Figure 5c. Lead shot in Bald Eagle digestive tract.

Figure 5d. Large piece of lead in Bald Eagle digestive tract.

and preferred item for scavenging. A youth deer season is held in mid-September, a special doe season in November, and the main shotgun seasons are in December, with an extended doe season in January. Cases of eagle poisonings peak in December and January. These expanded deer hunting opportunities could also make carcasses available for a longer timeframe during the eagle's wintering cycle. Nixon et al. (2001) estimated that the number of animals wounded but not retrieved could be 10% or more of total gun harvest. From 12,000 to 18,000 deer carcasses could have been available to eagles annually throughout the data collection timeframe (Figure 7). This does not account for deer poached and left in the field.

X-ray evidence of eagles and deer carcasses support the theory that lead shrapnel in lead slug wounded but not retrieved deer carcasses is a source of lead poisoning for Iowa wintering Bald Eagles. Hunt et al. (2006) found lead shrapnel readily available to avian scavengers in deer shot with lead rifle bullets, also. In clinical trials, less than 200 mg of ingested lead was enough to kill an eagle (Hoffman et al. 1981, Pattee et al. 1981). Thus a very small piece of shrapnel could be lethal to an eagle. Other x-ray evidence implicates lead shot used in upland game hunting. Timing of poisoning cases however seems more closely linked to deer harvest than upland game harvest. Eighty percent of pheasant harvest occurs within the first three weeks of the season, beginning the third weekend in October (IDNR 2007). Pheasant or rabbit carcasses would be more hidden than a large deer carcass and would be less likely to be available into February and March. It is illegal to hunt waterfowl with lead ammunition, so it is hoped that waterfowl would no longer be a source of secondary lead for eagles. The timing, however, of the waterfowl harvest closely coincides with pheasant harvest and most hunting is done early in the season and most waterfowl have moved south by the end of November. Wounded deer may not die immediately, they may die later in the winter or early spring as they are stressed by lower food availability and spring snows. Thus, fresh deer carcasses may become available as the winter progresses. Deer and, to some extent, upland game are thus likely sources of spent lead from the fall to early spring.

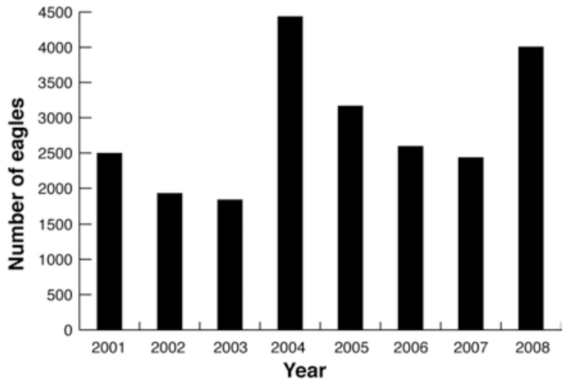


Figure 6a. Iowa mid-winter Bald Eagle survey.

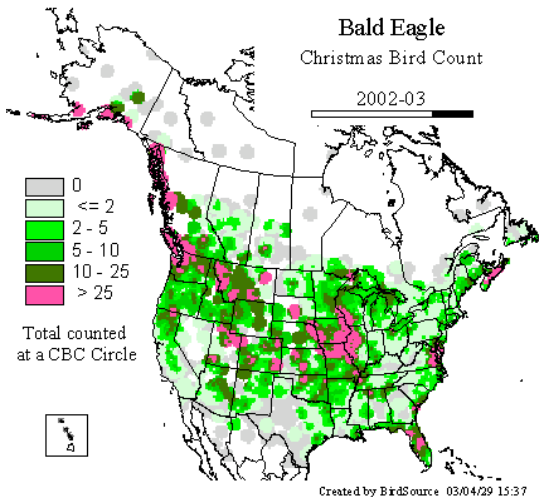


Figure 6b. Bald Eagle Christmas Bird Count Data.

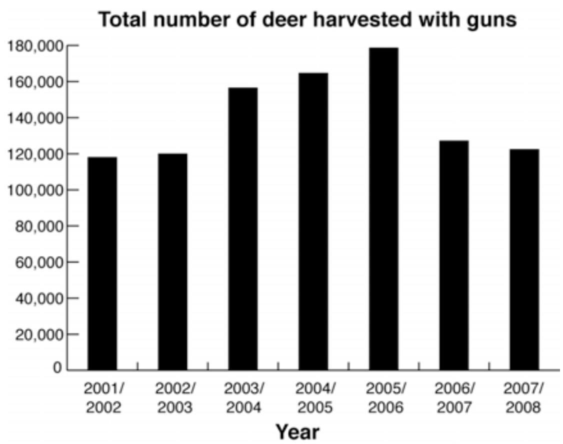


Figure 7. Deer Carcass Availability.

How much is too much? Preventable poisoning of protected wildlife species should not be an acceptable form of mortality. Lead poisoning deaths could be a population risk factor in a species that is at the top of its food web, is slow to reproduce, and should have a 20 to 25 year life span. Iowa wildlife rehabilitators have documented ten to twelve eagles dying each year in Iowa with abnormal lead levels. Not all eagles were able to be tested for lead, so this mortality rate due to lead may be an underestimation. This number also is only some fraction of the number of eagle deaths each year due to lead ingestion, as not all sick and dead eagles are found and brought in for testing. With over half of Bald Eagles admitted due to lead ingestion there is reason for alarm, concern, and action to prevent further mortality due to this factor. For comparison, more random events seem to occur at a much lower percentage of the total number of eagles admitted. Gunshot wounds, for example, were recorded in ten of the 82 eagles in this database (12.2%). The data do not indicate that the increasing number of Bald Eagles being admitted by Iowa wildlife rehabilitators is simply a function of the increasing numbers of eagles in wild populations. If this were the case, it would be expected that a variety of causes would be seen for admittance (miscellaneous trauma, fractures, starvation, disease, etc.), at percentages relative to that seen for gunshot wounds. This has been the case for other species. As Coopers Hawk (*Accipter cooperii*) populations have increased, rehabilitators have admitted an increasing number of them with a wide variety of problems (Cancilla pers. comm.). This has not been the case with Bald Eagles. As the numbers of Bald Eagles has increased, Iowa wildlife rehabilitators have admitted more of them but not with a variety of injuries, instead with one overwhelming cause; lead ingestion.

Thousands of eagles (up to one fifth of the lower 48 states' population) spend the winter in Iowa (IDNR 2007). With IDNR trying to reduce the deer herd with lengthened seasons and increased harvest, deer carcasses are readily available throughout the fall, winter, and early spring. These converging factors could cause a non- sustainable number of bald eagle deaths from lead ingestion annually. With the United States Fish and Wildlife Service (USFWS 2008) population estimates for Bald Eagles nearing 10,000 pair in the lower 48 states and the eagle's very recent removal from the endangered species list, there may not be an excess of individuals to compensate for this annual mortality on a major wintering ground. With delisting, Bald Eagle nesting and wintering habitat will no longer have mandatory protections. There is concern that loss of habitat may cause Bald Eagle populations to decrease. The Southwest Bald Eagle population (Arizona, New Mexico, and Mexico) has not shown a clear long-term increase in numbers and has a low productivity rate and a high adult mortality rate (RRF 2006). Sub-lethal effects of lead may effect reproductive success and shorten life span. There was a documented 10 year lag time with the decline and recovery of Bald Eagles from the effects of DDT, another poison (Bednarz et al. 1990). By the time a detectable change is seen in the number of breeding pairs, it may be too late to reverse those declines. Accurate breeding pair numbers, productivity, and winter survey data needs to be gathered to monitor Bald Eagle population health. Adult survival and turnover rate at historic nesting territories would be other good indicators of population health; these numbers are not available for Iowa nesters. It is estimated that there were 500,000 Bald Eagles living in what is now the lower 48 states at pre-settlement time. It is estimated there were more than 3,000 pairs on the Chesapeake Bay alone (Buelher 2000). They have endured bounties, chemical contamination, and habitat loss. With complete protection, they have returned to less than 10 % of their historic numbers, while other species of birds of prey have recovered completely from adversity. Peregrine Falcon (*Falco peregrinus*) numbers have returned to their pre-DDT levels with low adult turnover at nest sites (White et al. 2002). In many parts of the United States, Peregrine Falcons occur in higher numbers than ever known historically (GRIN 2008). Bald Eagles, a large, adaptable predator, have been unable to recover to numbers even near their historic levels (Buelher 2000). Perhaps the lethal and sub-lethal effects of lead are preventing a more robust return in Bald Eagle numbers across all of their range.

Educational efforts are underway to urge hunters to use solid copper deer slugs instead of lead. Deer hunters are reporting good success using the solid copper slugs. Many hunters have switched to copper slugs and/or muzzleloader bullets for better performance. They also have the added satisfaction of knowing that they will not contribute to secondary poisoning of wildlife. With a majority of hunters in our survey responding positively to the phase out of lead ammunition for wildlife and human health, it does not appear that hunters' attitudes will be a barrier to getting lead out of recreational activities.

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