Response to Comments for "Peer Review of *Lead Exposure and Effects to Scavenging Birds: A Review for the U.S. Fish and Wildlife Service* (prepared by *Atkins, North America*, April 2014)"

Prepared by Nancy Golden and Sarah Warner
July 1, 2014

Note: Original reviewer comments are in regular text. Responses of authors on are in bold.

REVIEWER 1

The "scientific uncertainties" that I listed above were extracted by me based upon my interpretation of the text written in the "Executive Summary" of this report. The additional scientific uncertainties I suggested for consideration are ideas I developed from reading other sources. This report does not "clearly identify and characterize scientific uncertainties" nor does it discuss "the potential implications of these uncertaities." As best I can tell this aspect of the report was not done or it is certainly not clearly indicated in the report. The "Discussion Points" boxes at the end of each section in the report are simply summaries of the previous text. For the Review of USFWS Review of Lead Exposure to Scavenging Birds Appendix B most part the points in the boxes are correct (as they relate to the text). I did not find a discussion of the implication of scientific uncertainties within this report.

Question 1. I believe that the objectives of the Report are clearly stated although not completely met. As I state above in my general comments, I do not see in this document a clear stand-alone statement of scientific uncertainties or a statement addressing the implications of these uncertainties within the Report. I believe the content of the Report is within stated parameters except when the parameters are not addressed (as in scientific uncertainties). I am not sure that the case reports (condors and eagles) provide that much additional support to the objectives of the Report. While they do provide greater detail about the two species, they do not introduce different concepts related to lead toxicosis. Stated differently, the core concepts of lead poisoning in scavenging birds are not exclusive to condors and eagles. I believe it is useful for the authors to consider shortening the Report by rethinking the value of the case reports as they relate to the issue of lead toxicosis.

- **The objectives have been restated to better align with the content and intentions of the report.**
- **The purpose of the case studies has been better defined to support their inclusion.**

Question 2. For the most part, I believe that the authors do summarize the text in the Discussion Points boxes. However, there is no discussion of the points. Rather, the statements in the boxes are re-statements, perhaps paraphrased, of material presented in the text.

- **Discussion points have been renamed “Key Points” to better support their intention.**

Box on page 19: the lead statement is that “lead toxicity to birds is extremely well understood……”. Yet, there are issues where information is not known (please see my list of scientific uncertainties above). Perhaps a better phrasing would be, “well documented” instead of “extremely well understood”.

- **Statement was reworded.**

The last statement in this box refers to the need of combining tissue concentrations of lead with clinical signs. There is no mention however, that the majority of birds presented for necropsy have no clinical signs. We are lucky to find the bird carcasses. This is an area of scientific uncertainty that needs discussion.

- **Text modified to address this issue**

Box on page 24: the fourth statement relates to the lead shot ban and the conservation of ducks and the birds that feed on ducks. The last paragraph of the section, first sentence ends: “…. and birds that prey on waterfowl”. Yet there are no data presented or referenced in the preceding text of this section on birds preying on waterfowl. All the information in the section is on waterfowl only.

- **This has been revised and now includes text regarding birds that prey on waterfowl.**

Box on page 26: last statement, “carcasses and offal with lead ammunition fragments are available and attractive to scavenging birds”. This implies that carcasses and offal that do not contain lead fragments are not attractive to scavenging birds?

- **Edited for clarity**

Box on page 30: last statement, “…group feeding behavior can enhance their vulnerability to lead exposure…….” This statement would benefit by an additional clarifying statement that multiple birds feeding on the same contaminated carcass become exposed and so more individuals within the same population are affected at the same time.

- **Text has been clarified**

Box on page 43: here in the last statement the authors state that clinical signs diagnostic of lead toxicosis may not always be exhibited despite known exposure. Here again we have a statement rather than a discussion. There are now two references to the importance of clinical signs but there is also the fact that not all poisoned live birds present with clinical signs and most carcasses

presented for necropsy to determine a cause of death do not have observed clinical signs prior to death. This issue needs to be discussed.

- **Text modified to address this issue**

Box on page 50: third statement: please avoid using the term “high” with regard to incidence of lead exposure in eagles as you have no reference to compare exposure rates. It is better to use “increased exposure” during hunting season.

- **Text has been revised**

Box on page 53: last statement: I understand what the authors are trying to get to but I think this needs more thought. I think the value of tissue concentration is understated in this Report. Please remember that lead is not supposed to be in anything alive. In general, birds submitted for necropsy have tissue levels of lead well above threshold levels. The presence of lead in the gastrointestinal tract is only indicative of exposure, not toxicosis. Tissue concentrations in the absence of clinical signs or presence of lead material are still diagnostic.

- **The statement is not meant to negate the value of tissue concentrations. On the contrary, key points are meant to relay that ammunition fragments need not be present to be diagnostic. The statement was modified for clarity. And yes, tissue concentrations can be diagnostic, but must be interpreted with caution: First, there are differences in species sensitivity to lead. Second, there are birds that have undergone chelation therapy (e.g. the condor population) whose tissue concentrations will have been altered in the process**.

Box on page 70-71: be careful using the term “significant” as there is no associated mathematical/statistical rigor applied to the statement. Here it is being used as a relative descriptor that is largely a value statement of the authors.

- **Text modified**

Question 3. I believe that the authors have accurately summarized the existing peer-reviewed scientific literature on the effects of lead on scavenging birds. They have also established, by providing information from the peer reviewed scientific literature, that spent lead ammunition including fragments of lead bullets are an important source of lead to these birds. I do not believe that there are instances in this Report where different but equally reasonable conclusions might be drawn that differ from the conclusions of this Report and is supported by the literature.

- **No response required**

Question 4. I believe that the authors have accurately summarized the data, analyses, and conclusions drawn by the authors of the scientific papers reviewed in the Report. The authors of the Report have drawn reasonable conclusions based upon the information they have complied for this report. The information the authors have compiled for the Report was written by qualified scientists who have published their results in reputable scholarly scientific journals.

- **No response required**

Question 5. I believe the authors of this Report would benefit by reading the following paper: Cababree, EJ and Baldwin LA. 2002. Defining hormesis. Human and Experimental Toxicology 21:91-97.

- **This paper was informative. The reference to hormetic response was not crucial and was removed to avoid misinterpretation.**

Question 6. I do not believe that there are other potential sources of lead exposure that should been considered by the authors of the Report.

- **No response required.**

Question 7. I do not understand this question. The "scientific foundation" of this Report is in the experimental design, data collected and analyzed, and conclusions drawn by the authors of the papers cited in the Report. The authors of the Report do not present any original data or analyses. They have drawn their conclusions based upon the research of others. The writing of the Report could be improved, terminology tightened, information better presented graphically, but these are editorial changes that have nothing to do with the scientific foundation of the Report.

- **No response required.**

Editorial comments

- **Appreciated and incorporated into text**

REVIEWER 2

1. The primary objectives for the document are ostensibly laid out on page 11 (indicated as such by the table of contents). Here it states that the objectives of the "paper" are "to gather and review Review of USFWS Review of Lead Exposure to Scavenging Birds current science on exposure and effects to wildlife from lead ammunition, and to address questions regarding scientific uncertainty." First, it is unclear what is meant by "paper." Is this document intended for publication? If so, in what format, and what is the intended outlet/readership? This issue should be addressed in the document in order to determine if it is suitable for its intended purpose.

The document gathers and reviews current science on exposure to, and effects from lead among birds in particular, but not for “wildlife” in general as stated here. Very little exposure data, and virtually no effect data are described for any species other than birds. As such, these objectives are either incorrect, or the document fails to address its stated purpose. The last portion of the objective refers vaguely to scientific uncertainty. One is left asking the question, “Uncertainty with regards to what?” It is difficult to determine if the document completes this objective, because it is, in and of itself, uncertain. Further, subsequent sections do not clearly identify what is uncertain. Clearly identifying areas of uncertainty, and then following up with data and information addressing areas of uncertainty would tremendously improve the outline, format, and flow of the document, and perhaps provide stronger support for Discussion Points included at the end of most sections.

Failure to provide a strong and specific objective statement at the outset of this document may have ultimately contributed to its seeming random and repetitive presentation of information. Clearly, there are significant amounts of information that fall within the parameters of the objective, but there are also significant amounts of material that seem to stray from the objectives (or are tangential at best). For example, there is an inordinate amount of information included on the ban of lead shot in waterfowl hunting. Without question, there are lessons to be learned from this historical event, but those lessons are not clearly spelled out, identified, or applied to the current crisis. Further, repetitive references and descriptions of bald eagles in the Great lakes has clear significance that informs about lead exposure and effects, but again, the take home message (specifically applied to all scavenging birds) is not clearly established. Another example which seems to veer from the topic is the passage dealing with alternative ammunition. Is this one of the “questions regarding scientific uncertainty” alluded to in the objective statement? If so, this and other scientific uncertainties should be clearly identified prior to each relevant section to assist the reader in understanding why issues are addressed in this document. Sub-objectives pertaining to each section could not be identified (and would be helpful), thus there did not appear to be an overall plan, or predetermined document outline.

- **the objectives have been rewritten to better support the intent (and contents) of the report**
- **repetitive information has been combined and superfluous information deleted**
- **the case studies have been shortened and incorporated into the “Occurrence of Lead” section**

2. In most instances, the authors draw correct conclusions from information presented in each section. However, there are instances where the authors appear to have overreached, or arrived at conclusions not entirely supported by information presented in preceding sections of the document. This reviewer will provide, in addition to comments written here, an accompanying PDF document identifying questionable Discussion Points and explaining why they do not

appear to be correct or sufficiently supported by information provided in the text. (See accompanying file in Appendix B).

- **these comments have been addressed individually**

3. The authors draw reasonable and scientifically sound conclusions from information presented, in most instances. However, there are instances where the authors do not appear to have drawn reasonable and scientifically sound conclusions, or they are not entirely supported by information presented. This reviewer will provide, in addition to comments written here, an accompanying PDF document identifying passages/assertions that do not appear to be reasonably sound conclusions or are not sufficiently supported by information provided in the text. (See accompanying file in Appendix B).

- **these comments have been addressed individually**

4. The majority of interpretations, analyses, and conclusions presented in this document are indeed based on the best available science. There is one significant exception, and one rather minor exception. The section on Toxicological Impacts of Lead in Birds, and more specifically, the Organism health response and effects section do not appear to contain sufficient information to fully understand some of the primary toxicological manifestations of lead exposure. Despite the fact that throughout the entire document neurological and neuromuscular deficits are described as symptoms of lead intoxication, nowhere does the document describe the mechanistic foundation(s) associated with these adverse effects, nor the apparent heightened sensitivity of developing organisms to the neurotoxic effects of lead.

- **This section has been expanded to address this information**

Of somewhat less importance is the reliance of the authors on the Vyas, 1999 reference. The authors seem to equate difficulties associated with finding passerine species following pesticide application with the troubles associated with locating dead or moribund condors. It is likely that most dead, injured, or sick wildlife are obscured from observation, but extrapolating from a dead robin to a condor is a bit extreme.

- **More references on carcass removal/scavenging have been included**

Other than these instances, there appear to be only a few additional peer-reviewed published papers that perhaps should have been considered for inclusion/integration in the document to ensure that it was based on the most current science. They are:
Burnett et al., 2013, Eggshell thinning and depressed hatching success of California condors reintroduced to Central California, The Auk 115(3)477-91.

- **the condor section has been revised to focus solely on lead as a cause of mortality**

Cogan et al., 2012, Analysis of California condor (Gymnogyps californianus) activity using satellite telemetry data, The Open Ornithology Journal 5:82-93.

- **this reference has been added**

Helander et al., 2009, Ingestion of lead from ammunition and lead concentrations in white-tailed sea eagles (Haliaeetus albicilla), Science of the Total Environment 407(21)5555-63. Addresses impacts of a partial lead ban (no changes in incidence of lead poisoning).

- **This paper is now referenced in two sections: sublethal effects, and geographic scope. While this paper does address a partial ban, it's similar - though not the same - as the ban on lead shot for waterfowl hunting. We chose not to discuss the details of a different geographic region without a comprehensive examination.**

Hunt, WG., 2012, Implications of sublethal lead exposure in avian scavengers, Journal of Raptor Research 46(4)389-393.

- **added to sublethal section**

5. This reviewer could not identify any seminal peer-reviewed papers that would enhance the quality of the document or contribute to alternate conclusions that are scientifically sound. However, there are a few papers (listed above) that might be considered for inclusion should revision occur.

- **no response required**

6. There do not appear to be any other significant known or potential sources of lead contamination that are not appropriately considered by the authors. That does not discount the fact that there may be isolated incidents wherein unusual circumstances lead to exposure among scavenging birds; a contingency that is appropriately acknowledged in the document. In fact, the authors tended to be overly conservative when acknowledging that sources other than lead ammunition may contribute to scavenger exposure. It seems quite reasonable to more forcefully discount potential for lead exposure among scavengers (particularly with reference to condors) from any source other than lead ammunition and lead paint as detailed within the document. Foraging and nesting behaviors would appear to limit scavenger exposure to only ammunition and microtrash (including paint chips). A more definitive statement to this effect would seem warranted based on information provided. There again, with uncertainty with regards to which types of scavenging birds (condors, vultures, eagles, other raptors, etc.) are the intended foci of this document, there may indeed be other unimagined sources. As far as condors, most likely not.

- **this section was reviewed critically for areas where more definitive statements could (or could not) be made**

7. The scientific foundation of this document is solid, sound, and reasonable. It appears to have been based on the latest and most relevant scientific data and studies. But, as stated above, the document does not appear to contain sufficient information to fully understand many of the neurotoxic effects associated with lead exposure. Specific mechanistic information is needed on neurological and neuromuscular deficits associated with lead intoxication, and it may be usefulto include information on lead-induced neurodeficits among developing organisms. There are numerous other instances where text presented within the document could be improved or clarified. These are detailed in an accompanying PDF document which identifies those sections and passages that are unclear, confusing, have alternate explanations/interpretations, or are not supported by information provided in the text or in the referenced literature (See accompanying file in Appendix B). Addressing those comments and/or providing clarification would likely serve to strengthen the scientific foundation of this document and clarify presentation thereof.

Specific comments from reviewer 2 embedded in report

Page: 6

- Pb is not absorbed directly into tissues per se. It is first absorbed across gut epithelium. This passage and similar others throughout the document oversimplify this process.
    - **The statements have been clarified where appropriate. However, where a simplified explanation suffices, it was left.**

- Not always, it "may" result....
    - **Sentence was revised to reflect comment.**

Page: 7

- bird's
    - **Sentence was revised to reflect comment.**

- Unclear as written. This assertion needs additional context or information. The tendency to group feed may also minimize the likelihood of exposure if the downed carcass does not contain lead.
    - **Further explanation was provided within the text.**

Page: 9

- Repetitive
    - **Sentences were revised to limit redundancy.**

Page: 10

- Incomplete sentence.
    - **Sentence was revised to reflect comment.**

- Suggest improvement of sentence. Should refer to "population level effects among bird species." Also, spent shot does not come from
    - **Sentence was revised to reflect comment.**

Page: 11

- All "wildlife"? Not all wildlife species are addressed in this document. The focus is, or is ostensibly to be scavenging birds. Suggest revision of this statement to reflect true focus.
    - **Sentence was revised to reflect comment.**

- This passage is vague and does little to help the reader understand 1) what uncertainty in this context actually is, and 2) what issues surrounding exposure and effects in "wildlife" or scavenging birds are uncertain or unclear. Suggest significant revision of objectives statement to help guide and focus the entire document.
    - **Objectives were revised and the passage changed to reflect the revision.**

- Eisler reference is for waterfowl only. This assertion suggests adverse effects in endangered species for over 100 years whereas the Endangered Species Act is nowhere near 100 years old.
    - **Sentence was revised to reflect comment.**

Page: 12

- ingested lead or
    - **Sentence was revised to reflect comment.**

- Not consistent with text on page 11 where "wildlife" appear to be the focus of this document.
    - **Sentence was revised to reflect comment.**

- Unclear as written. How did the percentage range in a finite sample of gizzards?
    - **Percent varied by species….clarified in text**

- What is the significance of this? Seems out of place.
    - **Left as written. Provides early identification of diagnostic lesions.**

Page: 13

- Unclear whether this section applies to all wildlife, birds, or all biological systems. Suggest it be limited to bird physiology and incorporate much of the other "effects" descriptions spread throughout the document.
    - **This section is couched within a section called “Toxicological impact of lead to birds” so yes, it is meant to describe effects to birds.**
- If this section was intended to be the definitive section on toxicity of Pb, it does not succeed as written. For example, there is little or no information on the neurological and neuromuscular effects of Pb exposure. These are critically important for explaining common manifestations of Pb-poisoning in birds (wing drop, paralysis, etc.). Further, if this section is to apply to all organisms as indicated by the header, it should address neurodeficits among developing organisms (which might significantly impact nestlings). This section does not adequately address the sequelae of Pb intoxication leading to secondary effects (immune dysfunction, reduced foraging, starvation, etc.)
    - **This section has been expanded to address this information**

- Finally, this section seems redundant with other sections appearing later in the document.
    - **Redundant passages were combined where possible**

Page: 17

- Need to clarify this point here as it becomes very important.
    - **Background information on the use of feathers for monitoring was moved here from the isotope section.**

Page: 18

- This is unclear. What is the difference? Should this be wet weight?
    - **Yes, it should be 10 ppm ww. Corrected in text.**

Page: 19

- This passage and others in this section suggest impacts may occur in nestlings as a result of sublethal exposures. Do estimates of mortality among condors include or consider this as a factor?
    - **No, this type of information is not included in mortality estimates. At this time, mortality from sublethal effects can only be inferred.**

- This is true, but little mechanistic information is provided, albeit lots of clinical symptoms are described herein.
    - **This statement has been revised.**

- Again, Pb is not absorbed directly into tissues. It is carried by blood and makes a rather circuitous route through enterohepatic circulation. Suggest not oversimplifying.
    - **The statement was modified for clarity. However, as compounds are generally not absorbed directly into tissues other than blood (itself a tissue), this comment could be made of anything ingested into the body.**

Page: 20

- It is unclear why this entire section is included. Suggest that it be streamlined and that only information pertaining to scavenging birds be included. The rest can easily be referenced.
    - **This section is included to discern the sources of lead ammunition still present for scavengers. This has been clarified in the Objectives, the section streamlined, and the table deleted.**

Page: 21

- Again, not sure why this is covered in this document. It could easily be referenced. Further, the appropriate references for the various events included in the table are not provided, limiting the table's utility.
    - **This section is included to lay out the sources of lead ammunition still present for scavengers. This has been clarified in the Objectives, the section streamlined, and the table deleted.**

Page: 24

- Again, it is not clear why this section was included. How does it relate to the scavenging bird issue? What is the take-home point or points here?
    - **This section is included to discern the sources of lead ammunition still present for scavengers. This has been clarified in the Objectives, the section streamlined, and the table deleted.**

- Grammatically challenged statement. "expose waterfowl and predatory birds"?
    - **This text has been revised.**

Page: 25

- How much? What percentage?
    - **Text was added to address this question**

- Does this include poaching estimates? If not, those data should be addressed.
    - **The reference cited does not include poaching estimates. If this information exists, we were unable to track it down.**

Page: 26

- What are the numbers on "expected shots fired"? For example, a prairie dog hunter would be expected to fire MANY more shots than a deer or elk hunter. It may be helpful to evaluate numbers based on expected rounds fired.
    - **We did not pursue this level of detail.**

- This is stated elsewhere and does not need to be repeated here. Not well supported by information presented in this section.
    - **An attempt was made to consolidate redundant information**

Page: 29

- Does this imply that vultures are needed for appropriate condor management? If so, should this document also address population levels and health of vulture populations?
    - **Don't know that this statement is fully supported by the description of vulture feeding behavior in this section. Perhaps if food were a limiting source this might be an issue? Beyond the scope of this discussion.**

Page: 30

- Not sure this is clearly established in this section. Logic pathway seems to be missing a few key steps.
    - **This statement has been revised.**
- This statement should be well-referenced. It should not be left for the reader to take this assertion on faith.
    - **This statement has been revised.**

Page: 35

- What types of varmints occur in condor ranges? How much hunting of varmints occurs?
    - **This is outside the scope of this section, bust estimates for varmints, where known, were included in the condor case study.**

Page: 36

- This statement is somewhat contrary to data presented. Copper is less frangible.
    - **This has been clarified in text**

- Grammatically challenged sentence. Unclear. Dissection of fragments?
    - **Revised**

Page: 37

- Unclear as written.
    - **Revised**

- Not clearly demonstrated. Larger fragments may result in larger "dose" when consumed.
    - **Modified slightly, but believe it's a reasonable conclusion that fragmentation increases bioavailability due to increased surface area, inability to avoid, and potential to expose multiple individuals with one bullet.**

- Larger than what?
    - **Revised**

Page: 38

- This is a very interesting and useful section. However, it needs to be related specifically back to condors and other scavengers (aside from raptors).
    - **Revised**

Page 40:

- This table could be made much stronger. First, it does not show outcomes associated with these treatments. Secondly, it would be more useful if data on percent of original mass eroded was included.
    - **A column on outcomes was added. Prefer to leave as total mass eroded to better compare doses. Also, percent original mass eroded was not presented in papers and would have to be estimated.**

Page 41:

- Is it a radiograph (as described elsewhere) or an x-ray? Also, it appears that more information was intended to be included here. Is something missing? Punctuation?
    - **The figure heading is correct as written.**

- Would be good to express as % of original dose.
    - **Not presented this way in papers, prefer not to estimate/extrapolate.**

Page: 42

- Repetitive.
    - **Revised**

- This table header is not well developed. It should be able to stand on its own without supporting text. All other figure and table headers/legends should be examined for completeness.
    - **Revised**

- Yet there is no mention of neurological or neuromuscular effects in the beginning of this document. These are quite important, obviously.

    - **The introductory sections have been revised to include descriptions of these effects.**

Page: 43

- This is the weakest of discussion point boxes presented in the document.
    - **The statements have been clarified to strengthen the conclusions presented**

- No, these things enhance dissolution of Pb when ingested by birds. Deposition of lead in tissues is a different process.
    - **Revised**

- Theoretically this could occur. Are there any published data that support this? Aren't the vast majority of pellets regurgitated or passed through the digestive tract before they are completely dissolved?
    - **Revised. The fate of the pellet would appear to be vary according to circumstances such as its size. There does not appear to be data related to the fate of most pellets.**

- Quite vague.
    - **Revised**

- It should also be clarified why these things are variable... due to timing of exposure, dose, and other factors.
    - **Statement was left as written**

- This is not well supported by information presented in this section.
    - **Revised**

Page: 44

- Yes, but it should also be noted that all other causes of mortality (aside from lead) are also subject to being undereported.
    - **Text revised**

- True, but the focus of the Vyas paper was pesticides, agroecosystems, and primarily passerine species. These are much less obvious than a condor. Suggest caution in extrapolating the Vyas 1999 reference too far.
    - **This section has been expanded to draw on a wider array of carcass removal and detection studies.**

Page: 45

- What is the point of this table? It is not clear how these references are addressed in the next section. What is the take-home point?
    - **Text revised**

Page: 46

- It would be very helpful to add a header or lead paragraph explaining what these vignettes are, why they are included, and what sets them apart from the references provided in table 5. Unclear, and in some cases, repetitive.
- These vignettes seem out of place, unnecessary, incomplete, or too abbreviated.
- Where? Incomplete, missing important descriptors.
- Where and when? Incomplete as written.
    - **The entire section has been revised.**

Page: 48

- al
- Information provided in support of these discussion points is not well-developed. It seems rather randomly presented.
- Is this the only ban discussed in this section? Unclear.
- Discussion point not well developed. Suggest rephrasing.
    - **The entire section has been revised.**

- It seems that this topic was just covered in the preceding section. Seems repetitive.
    - **This section has been merged with the previous section to avoid repetition.**

Page: 49

This study was just presented in the preceding section. As with much of the text in this document, the same information is presented over and over. The document should be revised completely to present a coherent summary of pertinent information.

- **This section has been merged with the previous section to avoid repetition.**

Page: 50

- Again, this section seems quite repetitive.
    - **This section has been merged with the previous section to avoid repetition.**

- Repetitive.
    - **This section has been merged with the previous section to avoid repetition.**

- Meaning unclear as written.
    - **Deleted statement, information is clear without**

Page: 51

- Were these confirmed to be Pb or metallic? Clarify.
    - **Revised to clarify lead**

Page: 52

- Where? Important detail omitted.
    - **Revised**
- All repetitive information
    - **This has been incorporated into the Occurrence of Lead section and referenced**

Page: 53

- Repetitive.
    - **This has been incorporated into the Occurrence of Lead section and referenced**
- Where has this been documented?
    - **Revised**

Page: 54

- Rephrase. Should read "elucidate how biota are exposed to this toxicant." Pd is not a toxin, it is a toxicant.
    - **Revised**
- Sentence structure needs help.
    - **Revised**

Page: 55

- Clarify blood from whom or what.
    - **Revised**

Page: 59

- Again, Pb not absorbed from source into tissue. Also, this statement is leading, and not well-supported by information provided.
    - **Blood, a tissue, is the first site of absorption from the gut. The statement was revised for clarity, but believe is supported by the material presented.**
- On page 17 it states that older feathers are less reliable.
    - **This is true, that is why concentrations must be interpreted with caution and in conjunction with other information**
- This is a weak and abbreviated reference. Describe more fully or remove.
    - **Description has been strengthened**

Page: 60

- Populations don't "suffer," they increase, decrease, or remain stable. Too dramatic.

    - **There are several definitions of suffer. In this case it is used to mean “sustain injury, disadvantage, or loss” which is an appropriate use in this sentence.**

Page: 62

- Did not think it possible for waterfowl to ingest shotgun shells.
    - **Should be lead pellets; corrected**

Page: 64

- More than "less likely"... more like "exceedingly unlikely."
    - **The statement is accurate as written**

Page: 65

- Not depicted on the map.... only a blue line that is not even located in the Great Lakes. Clarify, and perhaps include an outline of where the referenced population resides.
    - **This map was removed as case studies were shortened and incorporated into the Occurrence of Lead section.**

Page: 68

- Self evident since deer made up over 50% of castings?
    - **Modified**
- Vyas does not address bald eagles. Use of reference in this manner is questionable.
    - **The Vyas reference, where it continues to be used, has been augmented with additional references on carcass removal/scavenging.**
- Specify the level.
    - **All threshold levels reported in papers have been added.**

Page: 69

- Deer hunting lasts until April???
    - **These months represent when eagles were admitted.**

Page: 70

- This section is unclear and confusing as written. Suggest complete revision.
    - **This section was deemed outside the scope of the report and removed.**
- The phrase that "the loss rate of dead birds may be up to 98% is somewhat humorous. It would seem that 100% of dead birds would be lost?
    - **Yes, a little funny as written. It’s the loss rate to scavengers within a certain time period. Corrected where used elsewhere.**
- Compared to what? Use of relative terms requires that appropriate context be added.
    - **This box was deleted when sections were combined.**

Page: 71

- Grammatically challenged.

- s
- Should be "Data demonstrate a correlation between .... and ...."
    - **This box was deleted when sections were combined.**

Page: 73

- Some historical context would be useful here. Clearly there has been a recovery plan in effect for quite some time. Also, the plan has been revised numerous times. A reader unfamiliar with this history will find this confusing. Appropriate references should be cited as well.
    - **This condor case study was shortened and this section removed**
- This entire section is repetitive. Information provided here is present in other sections of the document. maybe refer the reader to those sections. Otherwise, redundant.
    - **Agreed, repetitive information was removed and new information moved to the appropriate section**

Page: 74

- This is the first instance where condors are described as anything other than scavengers. Do they actually "take" small mammals, i.e., hunt, kill, and eat them. This changes things dramatically if true.
    - **No, they scavenge small mammals. Changed in text.**
- Not all carcasses are left behind. Clarify, and add percentages left behind if available.
    - **It's true that this represents a maximum number, but there is no information on the percentage left behind. Wounding rates, where known, are presented in prior sections.**

Page: 75

- Vague. List exact physiological process which aids in increased absorption.
    - **This paragraph was deleted as being repetitive with the physiology section, which includes greater detail.**

Page: 76

- 9+12+3=24, not 23. Clarify.
    - **This section has been modified**
- What were the other causes? Leading natural causes? These are needed for full disclosure. Should also reference Figure 11.
    - **This section has been refined to focus solely on lead exposure**

Page: 77

- Powerlines appear almost as bad as Pb poisoning. Yet nowhere in the document are the "retraining" procedures listed which serve to reducecollisions with powerlines. This is important context for this graph. Also, when you add mortality from powerlines and microtrash, they exceedPb poisoning. One might easily reach the conclusion that

powerlines and trash should be removed in order to preserve condors before lead is dealt with.

- **This graph was removed and the section refined to focus solely on lead exposure. Microtrash is covered in depth in the section on alternate sources of lead.**

Page: 78

- Would be very useful to see these data in a graph.
  - **This section has been refined to focus solely on lead exposure**

Page: 79

- Ed
  - **corrected**

Page: 80

- Unclear as written.
  - **Revised**
- Not supported by Figure 10 which shows that wild hatchlings are being added to the population (light blue shaded area).
  - **Figure 10 was removed and discussion box modified**

Page: 82

- True, but these protocols may need to be reviewed and revised to account for differences in projectiles (bullets and slugs) versus shot.
  - **Perhaps, but we can used the data comparatively now and extrapolate as appropriate**

Page: 85

- ??? if they are non-significant, why mention them?
  - **Revised – meant to imply that adverse effects were not found**

Page: 86

- Maybe, as stated above, these protocols need to be reviewed and revised to account for differences in projectiles versus shot.
  - **Yes, but I still think it's a fair statement to say that the data can be extrapolated. In the field of wildlife toxicology we are generally in the position of extrapolating from the data we have to the data we need, taking whatever differences that are necessary into account.**

REVIEWER 3

Question 1. The content of the report appears to lie within the bounds of the objectives specified.

- **No response required**

Question 2. I find no cases where conclusions appear not to be supported by materials presented.

- **No response required**

Question 3. I agree with the authors in their interpretations and conclusions.

- **No response required**

Question 4. See Question 7 for instances where the report would benefit from amplifying discussions and references

- **No response required**

Question 5. See Question 7 for a list of references that would enhance the scientific quality of the review

- **No response required**

Question 6. I am not aware of additional credible potential sources of lead contamination that should be addressed. The lead in batteries might be suggested, but it is difficult to envision circumstances where scavenging birds would be exposed to this source and I am not aware of any examples here. Perhaps some brief comments could be added on this potential source.

- **We chose not to include lead in batteries as we did not find any evidence of this an exposure route for birds.**

Question 7. I find the scientific foundation of the review to be reasonable, but believe it can be strengthened is a number of respects, as follows:

Page 27, paragraph 2, line 6. Authors may want to add some discussion here of the following issue: Some large vultures are known to collect bone as diet for nestlings, presumably to meet calcium needs for growth, and it is possible that such species may preferentially ingest small hard objects that they encounter in the flesh of carcasses, including lead ammunition fragments. Although I am not aware of any rigorous documentation of such a tendency, it appears to be consistent with a known tendency for California Condors to often pass by large carcasses (which have little bone material small enough to be ingestible) to feed on smaller carcasses (with much more ingestible bone). Granted there may be other reasollinsons for condors to prefer small carcasses, such as ease of penetration of hides, but it is noteworthy that studies of bones found in condor nests (e.g., Collins et al. 2000) indicate a heavy emphasis on bones of relatively small

mammalian species, such as squirrels and rabbits, and relatively few bones of adult large mammals such as cattle and deer. If condors have a preferential tendency to ingest small hard materials encountered in the flesh of carcasses, such as ammunition fragments, this may increase their exposure to lead (see discussion in Snyder and Snyder 2005).

- **An interesting suggestion though there does not seem like much data available to support or refute the theory. The Collins et al data is from the 1980's – before captive rearing. The new nest remains data (Mee 2007) found few bones remaining in the nest and a large variety of objects that were not necessarily explained by the need for calcium (lower percentage of white objects than seen in other gyps species). There did not seem to be a consensus in the literature on the collection of bone to meet calcium needs.**

Also, somewhere in the review, and I am not sure exactly where, there should be some discussion of the low frequency with which condors regurgitate pellets of indigestible material such as fur, which is a potential route for reducing exposure to ingested lead objects. Compared to most large raptors, pellet casting is quite rare in condors, as discussed in Snyder and Snyder (2005), probably because condors ingest little fur in feeding and concentrate on soft tissues.

- **Comparative frequency of regurgitation among species was not discussed, though could potential provide an additional line of evidence to explain condor exposure/sensitivity**

Page 30, last paragraph: With respect to scavengers ingesting whole bullets, it is relevant to mention a case documented by Snyder et al. (1986) where sifting of the substrate of a formerly active condor nest yielded a nearly whole lead bullet that had evidently been fired into the nest site, judging from distinctive rock grains embedded in the head of the bullet, but which had evidently been later ingested by a condor (most likely a nestling), judging from mammalian fur packed into the hollow core of the bullet. Whether the bullet had caused any mortality of condors, either by direct impact or by later ingestion, was unknown, but once present in a condor nest cave such a bullet could potentially poison successive generations of condors, as condor chicks readily ingest hard objects from their nest substrates, and such a bullet could potentially pass through the guts of multiple chicks over the years, converting the nest site into a reproductive "black hole."

- **A discussion of this reference was added**

Page 43, bottom paragraph, line 5. This paragraph needs a better explanation for why data were limited to examples after 1991. Waterfowl surely did not suddenly become clean of lead fragments on that date and still continue to show some contamination today. Perhaps the 1991 date was chosen to reveal whether or not exposure of various species to lead continued despite

the 1991 ban on lead shot for waterfowl? Needs clarification.

- **This was clarified in the text**

Page 48, bottom paragraph. The correlation of lead contamination with hunting seasons appears to be one of the most powerful arguments implicating exposure to lead ammunitions, as opposed to other sources of lead. Nevertheless, there is no reason to expect poaching activities to be limited to legal hunting seasons, and where year-round poaching becomes a major source of contaminated carcasses, the correlation with hunting seasons may be weakened *without* indicating that the contamination might be coming from sources other than ammunitions. Some discussion of this issue would be beneficial. At least several decades ago, deer poaching was very common in the range of California Condors in California (more than half the deer shot, by some estimates), so correlations of contamination events with hunting seasons should not be expected to always be very strong, even in locations where *all* contamination might be produced by ammunitions.

- **Text was added regarding poaching in the Temporal Trends section, but further detail regarding poaching estimates was not available**

Another sort of lead-ammunition contamination within California Condor range that was not strictly confined to hunting seasons was the dispatch of coyotes caught in leghold traps by the Animal Damage Control (ADC) branch of the USFWS up until 1984 (see discussion in Snyder and Snyder 2000). Thus, part of the problem of lead contamination of condors may have been due to operations of the Service itself.

- **Historical sources of lead that were unlikely to be contributing to current exposure were not discussed**

Page 71, paragraph 1 under Case Study 2, lines 4-6. The sentence ending in "(Grantham)" is OK for early historical times, but it does not accurately portray the state of knowledge regarding causes of the condor's decline in the 1980s. Suggest insert several sentences here to give a more thorough indication of how the lead issue came to the forefront with condors, as follows: Causes of the condor decline in the 1980s were under intensive study by the USFWS and primarily implicated excessive mortality, at least in part due to lead poisoning, while breeding effort and success appeared to lie within normal expected limits (Meretsky et al. 2000, Snyder 2007). No persuasive evidence for significant stress from shooting, DDE contamination, or declining food supplies was found (Snyder and Snyder 2000, Snyder and Meretsky 2003). That lead poisoning may have been the main source of excessive mortality was suggested by (1) three documented condor deaths to lead contamination, (2) frequent lead contamination of living blood-sampled condors, (3) most mortalities occurring during the hunting season, and (3) almost identical mortality rates in juvenile condors as in adults. The lack of age dependency in lead

contamination found in the study of Golden Eagles by Pattee et al. (1990) seems consistent with this latter finding. The growing evidence for lead contamination problems in the species, together with a loss of 40% of the wild population over the winter of 1984-85, led to a decision by the California Fish and Game Commission and the USFWS in 1985 to bring all wild California Condors into captivity, as there was no politically feasible way to end the lead contamination threat in the wild in a timely manner.

- **This information was removed from the case study in order to streamline and focus solely on lead-related mortality in the reintroduced population**

Page 73, line 20. DDE normally operates through reproductive stress, not mortality. The evidence of DDT/DDE stress in the current coastal population is not persuasive. The paper of Burnett et al. (2013) found no significant correlation of DDE with eggshell thinning, and although this paper claimed a relationship of DDE levels with shell abnormalities, it provided no credible quantitative evidence linking these variables. Snyder and Meretsky (2003) found no relationship between shell abnormalities and DDE levels for the southern California population of the 1980s and likewise they were unable to document a persuasive correlation between DDE and shell thinning in this population. The paper of Kiff et al. (1979) has not proved replicable in its results and conclusions.

- **This section was removed and the case study limited to just lead as a cause of mortality**

Page 74, paragraph 2, third line before end. Should add a reference to Meretsky and Snyder (1992) after “supplies”

Reference added

References cited in the above paragraphs

Burnett, L.J., K.J. Sorensen, J. Brandt, E. Sanhaus, D. Ciani, M. Clark, C. David, J. Theule, S. Kasielki, and R.W. Risebrough. 2013. Eggshell thinning and depressed hatching success of California Condors reintroduced to central California. Condor 115:477-491.

Collins, P.W., N.F.R. Snyder, and S.D. Emslie. 2000. Faunal remains in California Condor nest

Kiff, L.F., D.B. Peakall, and S.R. Wilbur. 1979. Recent changes in California Condor eggshells. Condor 81:166-172.

Meretsky, V.J. and N.F.R. Snyder. 1992. Range use and movements of California Condors. Condor 94:313-335.

- added

Meretsky, V.J., N.F.R. Snyder, S.R. Beissinger, D.A. Clendenen, and J.W. Wiley, 2000. Demography of the California Condor: implications for reestablishment. Conservation Biology 14:947-967.

Pattee, O.H., P.H. Bloom, J.M. Scott, and M.R. Smith 1990. Lead hazards within the range of the California Condor. Condor 92:931-937.

Snyder, N.F.R. 2007. Limiting factors for wild California Condors, pp 9-33 *in* California Condors in the 21st Century (A. Mee and L. Hall, eds.). The Nuttall Ornithological Club and the American Ornithologists' Union.

Snyder, N.F.R., and V.J. Meretsky. 2003. California Condors and DDE: a re-evaluation. Ibis 145:136-151.

Snyder, N.F.R., R.R. Ramey, and F.C. Sibley. 1986. Nest-site biology of the California Condor. Condor 88:229-241

Snyder, N.F.R., and H.A. Snyder. 2000. The California Condor, a saga of natural history and conservation. Academic Press, London.

Snyder, N.F.R., and H.A. Snyder. 2005. Introduction to the California Condor. University of California Press, Berkeley.

Some Typos and other Minor Confusions deserving correction:

- **These have been corrected in text**

REVEIWER 4

This report reviews much of the available scientific literature concerning exposure of scavenging birds to lead, and the toxicological implications. Although corvids are considered briefly, the focus is on raptorial birds, with in-depth evaluation of two case studies, the Bald Eagle and the California Condor. Although not stated as such (see more below), the tacit objective of the report is to make a case for restrictions on the use of lead projectiles for hunting. The report makes a strong case that California Condor populations continue to be impacted by lead from hunting projectiles, and that without further restrictions, populations will not thrive and expand, despite supplementation from captive breeding and rehabilitative interventions. The report also makes a case that the population(s) of Bald Eagles breeding and wintering in the Great Lakes is significantly impacted by exposure to the residues from lead projectile use. The report could make a stronger case that the problem is much broader, in fact continental, in scope. A comprehensive tabular summary of the

literature on lead exposure and poisoning of wildlife across the U.S or preferably all of North America, possibly with a map showing the spatial scope, would help make this case. In the process it would highlight regions for which data is lacking. There are also a number of specific elements of the report and the scientific basis that could be strengthened.

Question 1: The stated objectives are as follows: "… to gather and review current science on exposure and effects to wildlife from lead ammunition, and to address questions regarding scientific uncertainty. While general toxicity of lead will be reviewed, the specific focus will be scientific literature regarding effects to scavenging birds from secondary poisoning." The objectives are restated in the shaded box on P.12. The objectives are clear enough, to review science relevant to lead poisoning of scavenging birds, as distinct from, for example, from waterfowl or upland game birds. However, the report goes further in considering alternative materials than lead, and in making a case for banning or restricting use of lead ammunition. This should be included in the stated objectives or removed from the report. For example, in the section on P. 30 "Bioavailability of ammunition to birds: Fragmentation", the authors compare fragmentation and availability of alternatives to lead, particularly, copper. While valid in the broader context, this section is not within the scope of the stated objectives. The section beginning on P. 81, "Toxicity of alternative metals used in ammunition" goes beyond the stated objectives. In the objective statement, the authors propose to 'address questions regarding scientific uncertainty'. Some further detail or clarity would be useful here. Is it uncertainty around variation in exposure, related to diet, foraging range, ability to detect and regurgitate pellets, in toxicity, for example, variation in species sensitivity to lead, chronic toxicity and survival in the wild under multiple stressors, etc.?

- **The objectives have been restated to better align with the content and intentions of the report.**

2. Generally the authors do a reasonable job of drawing the correct conclusions for each section of the report. Some exceptions are noted below:

Box 2, P 19-20. Bullet 1 in this box is an overstatement of the situation. I would suggest rewording as follows: "Lead toxicity in birds has been studied in a variety of species and is relatively well understood". Whereas, the progression of acute and chronic poisoning of birds dosed with or exposed to lead is well understood, there are still many outstanding questions of relevance to impacts of lead on wild bird populations. For example, little is known, although much can be surmised from the mammalian literature, about the impact of early developmental exposure of lead on the brain and, therefore, learning and subsequent survival and reproductive success in birds. We have no idea of threshold values in nestling blood, for example, that could be associated with chronic and significant effects in later life. The few available studies are summarized on P 18-19.

- **This sentence has been reworded**

Bullet 4, while likely true and stated cautiously ("…may render…"), is still an overstatement based on the available literature.

- **Statement was left as written. As it is very difficult to study the consequences of sublethal effects on wild animals, we may never be able to definitively gather this data. However, we believe that it is reasonable to conclude that sublethal effects observed in a controlled setting may have a consequence to fitness even if we cannot directly measure them at this time.**

Discussion Points box, P 48 – Note double wording problem in Bullet 1.

- **Corrected**

Discussion Points box, P 70 – Note wording problem in Bullet 4.

- **Corrected.**

Discussion Points box, P 81 – Bullet 8 - discussion and conclusion on use of blood lead levels. Although the statement about the relatively rapid clearance of lead from blood is likely to be generally correct, this conclusion is based and supported by reference to Finkelstein et al 2012 study of California Condors. However, there is neither data on kinetics of lead in the Finkelstein paper, nor a primary reference. The supporting reference used by Finkelstein et al is unpublished report by Fry and Mauer 2003. The kinetics of lead uptake and clearance from blood, particularly in the case of ingestion of lead particles, is likely to be complex. Whereas, it is true that annual blood sampling as an approach for monitoring lead exposure in a wild population, such as the condor, probably would underestimate the degree of exposure, as stated in the report, the authors need to put these arguments on a sound footing. See for a start:

- **A discussion of blood lead monitoring was included in the condor case study text. It has been modified and kept in the modified case study.**

Barbosa Jr, F., Tanus-Santos, J. E., Gerlach, R. F., & Parsons, P. J. (2005). A critical review of biomarkers used for monitoring human exposure to lead: advantages, limitations, and future needs. *Environmental health perspectives*, 1669-1674.

- **This reference has been included.**

3. In response to this question, the report's conclusions, as described on Pages 86 and 87, are examined in turn:

- “Scientific evidence points to lead ammunition as the most frequent cause of mortality in lead exposure cases”
A strong case has been made to support that conclusion.

- **No response required**

- “A suite of evidence exists to support this conclusion, including the behavioral ecology and physiology of scavenging birds…”
A reasonably strong case has been made that aspects of the foraging behavior, including group foraging and flocking at carcasses is important as a factor to avian scavenger exposure to lead ammunition from game carcasses. Similarly, the particular gut physiology is also important in the digestion of ingested lead particles. I think that a good case has been made on this topic.

- **No response required**

- “… their sensitivity as exhibited in controlled dosing studies…”
Presumably this means ‘relative’ sensitivity in a toxicological sense. In this case, I do not believe that are good comparative data from controlled dosing studies under the same experimental conditions with different species of birds to show that scavenging birds, particularly raptors and vultures, are relatively more sensitive to lead.

- **Not meant to imply relative sensitivity merely that these species are susceptible to lead ammunition in the form and dose to which they may be exposed in the wild. This statement has been clarified.**

- “… the bioavailability of lead ammunition due to fragmentation, recovery of ingested lead fragments or pellets…observations of birds feeding…”-
These part of the conclusions statement is particularly well examined and supported in the report.

- **No response required**

- “…isotopic analyses relating tissue concentrations to ammunition…”
The data on this topic is somewhat complex, but has been given reasonable treatment.

- **No response required**

- ...patterns of mortality coincident with hunting seasons…”
This available data are consistent with the overall conclusion.

- **No response required**

- "…diagnosis of lead poisoning by well-established tissue thresholds and clinical signs…"
There is a reasonable body of published literature that supports the conclusions of the report.

- **No response required**

"...lack of abundant evidence for other sources of lead…"
Lead from mining sources would benefit from further evaluation. See below.

- **The mining section was revised and references added where appropriate.**

However, paragraph 2 of the concluding statement is not consistent with stated objectives of the report to review the literature. It deals with measures that could be taken to reduce the degree of exposure and poisoning. Further evaluation of the conclusions in paragraph 2: The only conclusion that is really feasible and should be listed first is: "Lead can be replaced in ammunition by alternative metals…" But the report does not address many aspects of this possible action, so this conclusion should be removed or the report should address this topic more comprehensively from objectives through to assessment of relevant information such as effectiveness of alternatives, cost factors, and essentially socio-economic and legal factors such likelihood of broad acceptance by hunting communities, degree of compliance, whether a broad ban on lead ammunition is readily enforceable, politics, such as the response of other jurisdictions with legal authority over hunting, which in the U.S. presumably means state governments, etc.

- **The conclusion was narrowed to better address the objectives of the report.**

4. The review draws heavily on two case studies, the Great Lakes Bald Eagle and the California Condor. Given that the geographical focus of the work is the U.S., those are logical choices. They are also well documented case studies with large sample sizes in one case, and an extensive body of supporting research in the other. Some other relevant U.S. work that is not cited:

Pagel, J. E., Sharpe, P. B., Garcelon, D. K., Little, A. E., Taylor, S. K., Faulkner, K. R., & Gorbics, C. S. (2012). Exposure of bald eagles to lead on the northern Channel Islands, California. *Journal of Raptor Research*, *46*(2), 168-176.

- **added**

There is also a broader literature on lead exposure and poisoning of eagles in western Canada, mainly by Mark Wayland and colleagues, that is relevant and would be supportive of the report's conclusions, e.g. (and works listed on p. A-25):

Langelier, K. M., Andress, C. E., Grey, T. K., Wooldridge, C., Lewis, R. J., & Marchetti, R.

(1991). Lead poisoning in bald eagles in British Columbia. *The Canadian Veterinary Journal*, *32*(2), 108.

- **A discussion of the scope of the report was added to the objectives and narrowed to the United States. These references were cited in referral to similar circumstances in Canada, but not discussed.**

Elliott, J.E., K.M. Langelier, A.M. Scheuhammer, P.H. Sinclair, P.E. Whitehead. 1992. Incidence of lead poisoning in Bald Eagles and lead shot in waterfowl gizzards from British Columbia, 1988-91. *Canadian Wildlife Service, Progress Notes*, Ottawa, ON, No. 200, 7pp. NOTE: the above paper is incorrectly cited in the Reference list, and also is incorrectly listed in Table 5 as an example of lead exposure after "the 1991 lead shot ban". The data in the report cover the period up until 1991.

- **This reference was removed from the table, but corrected in the literature list.**

Also, note, that the title of Table 5 is inaccurate. The 1991 ban was not North American wide. British Columbia banned lead shot for water fowl hunting in 1996, but the national ban in Canada was not implemented until 1999. The history of regulatory decisions is detailed in the following article:
Scheuhammer, A. M., & Thomas, V. G. (2011). Eliminating Lead from Recreational Shooting and Angling: Relating Wildlife Science to Environmental Policy and Regulation in North America. In *Wildlife Ecotoxicology* (pp. 359-382). Springer New York.

- **The table was corrected to contain only information from the United States, and the title changed to reflect that.**

More Western Canadian lead and raptor studies:
Miller, M. J., Restani, M., Harmata, A. R., Bortolotti, G. R., & Wayland, M. E. (1998). A comparison of blood lead levels in bald eagles from two regions on the great plains of North America. *Journal of Wildlife Diseases*, *34*(4), 704-714.

Wayland, M., Neugebauer, E., & Bollinger, T. (1999). Concentrations of lead in liver, kidney, and bone of bald and golden eagles. *Archives of environmental contamination and toxicology*, *37*(2), 267-272.

Miller, M. J. R., Wayland, M. E., & Bortolotti, G. R. (2001). Exposure of migrant bald eagles to lead in prairie Canada. *Environmental Pollution*, *112*(2), 153-162.

Miller, M. J., Wayland, M. E., & Bortolotti, G. R. (2001). Hemograms for and nutritional condition of migrant bald eagles tested for exposure to lead. *Journal of wildlife diseases*, *37*(3),

481-488.

Miller, M. J. R., Wayland, M. E., Dzus, E. H., & Bortolotti, G. R. (2000). Availability and ingestion of lead shotshell pellets by migrant Bald Eagles in Saskatchewan. *Journal of Raptor Research*, *34*(3), 167-174.

Wayland, M., Wilson, L. K., Elliott, J. E., Miller, M. J. R., Bollinger, T., McAdie, M., ... & Froese, J. M. W. (2003). Mortality, morbidity, and lead poisoning of eagles in western Canada, 1986-98. *Journal of Raptor Research*, *37*(1), 8-18.

- **A discussion of the scope of the report was added to the objectives and narrowed to the United States. These references were cited in referral to similar circumstances in Canada, but not discussed.**

There is a paper (Peterson, C.A., S.L. Lee and J.E. Elliott. 2001. Scavenging of waterfowl carcasses by avian predators in the Fraser River delta of British Columbia. *Journal of Field Ornithology* 72: 150-159) which examines and describes avian scavenging on waterfowl carcasses. Although concerned originally with pesticide poisoning, the paper shows how various scavengers are attracted to carcasses and a single carcass can result in a large congregation of eagles. It is pertinent to the statements at L 1 and the end of para 2, P 27, P 28, P 29, P 44.

- **Results from this study were incorporated into the sections referenced.**

That study also found that a variety of raptor species, in addition to the normally recognized avian scavengers, were drawn to and attempt to feed on duck carcasses.

- **Defined what species are being addressed, and how, in objectives**

Related to that work, studies of pesticide poisoning of raptors is potentially relevant to lead exposure and poisoning. Elliott et al (Elliott, J.E., A. Birmingham, L.K. Wilson, M. McAdie, and P. Mineau. 2008. Fonofos poisons raptors and waterfowl several months after labeled application. *Environmental Toxicology & Chemistry*. 27:452-460) related an increase incidence of pesticide poisoned eagles to population recovery in south western British Columbia. There are parallels to lead exposure as the eagles were exposed to pesticides from feeding on carcasses of ducks which had ingested pesticides granules while feeding during winter in farmed fields, treated the previous spring.

- **This paper was referenced in regard to carcass removal and detection.**

There is some excellent work on a the congeneric White-tailed Sea Eagle *Haliaeetus albicilla* from Germany that perhaps would provide another case study, or should at least be cited and

considered more than it is. The overall landscapes of the two countries differ, in that the U.S. still has much larger expanses of less developed and intensively managed land. However, there are also many similarities. Deer species in particular are heavily hunted in both countries, as are upland small game and wild pigs. The discarded carcasses and offal piles provide a continuing source of lead. These two *Haliaeetus* species are almost indistinguishable in terms of ecology and behavior. The report refers to some of the work done in Germany, such as the one cited paper by Krone; however, there are other related papers, and likely also relevant grey literature that possibly could be obtained by contacting Dr. Oliver Krone. See for example:
Nadjafzadeh, M., Hofer, H., & Krone, O. (2013). The link between **feeding ecology** and lead poisoning in white-tailed eagles. *The Journal of Wildlife Management*, *77*(1), 48-57.

- **Though a good case study, we opted to focus solely on U.S. species where we could better review all aspects of exposure such as regulations, types/extent of hunting, other sources of lead, etc.**

The socio-economic situation in Germany is also comparable with regard to attempts to mitigate lead poisoning of raptors in that both countries have large, powerful and conservative hunting lobbies. See for example:
Trinogga, A., Fritsch, G., Hofer, H., & Krone, O. (2013). Are lead-free hunting rifle bullets as effective at killing wildlife as conventional lead bullets? A comparison based on wound size and morphology. *Science of the Total Environment*, *443*, 226-232.

- **Outside the scope of report**

Other highly relevant European work on lead exposure and poisoning in Haliaeetus specifically comes from Sweden. It is work that could help support the scientific conclusions of this report:
Helander, B., Axelsson, J., Borg, H., Holm, K., & Bignert, A. (2009). Ingestion of lead from ammunition and lead concentrations in white-tailed sea eagles (< i> Haliaeetus albicilla</i>) in Sweden. *Science of the total environment*, *407*(21), 5555-5563.

- **(Sweden) A discussion of the scope of the report was added to the objectives and narrowed to the United States. These references were cited in referral to similar circumstances worldwide, but not discussed.**

From elsewhere in Europe:
Fernandez, J. R. R., Höfle, U., Mateo, R., de Francisco, O. N., Abbott, R., Acevedo, P., & Blanco, J. M. (2011). Assessment of lead exposure in Spanish imperial eagle (Aquila adalberti) from spent ammunition in central Spain. *Ecotoxicology*, *20*(4), 670-681.

Hernández, M., & Margalida, A. (2009). Assessing the risk of lead exposure for the conservation of the endangered Pyrenean bearded vulture (< i> Gypaetus barbatus</i>) population.

Environmental Research, *109*(7), 837-842.

Kenntner, N., Crettenand, Y., Fünfstück, H. J., Janovsky, M., & Tataruch, F. (2007). Lead poisoning and heavy metal exposure of golden eagles (Aquila chrysaetos) from the European Alps. *Journal of Ornithology*, *148*(2), 173-177.

Knott, J., Gilbert, J., Hoccom, D. G., & Green, R. E. (2010). Implications for wildlife and humans of dietary exposure to lead from fragments of lead rifle bullets in deer shot in the UK. *Science of the total environment*, *409*(1), 95-99.

Komosa, A., & Kitowski, I. (2008). Elevated lead concentration in skeletons of diurnal birds of prey Falconioformes and owls Strigiformes from eastern Poland—ecological approach and review. Ecol. *Chem. Eng. S*, *15*, 349-358.

Mateo, R., Cadenas, R., Manez, M., & Guitart, R. (2001). Lead shot ingestion in two raptor species from Doñana, Spain. *Ecotoxicology and Environmental Safety*, *48*(1), 6-10.

- **(Europe) A discussion of the scope of the report was added to the objectives and narrowed to the United States. These references were cited in referral to similar circumstances worldwide, but not discussed.**

From other localities:

Nam, D. H., & Lee, D. P. (2009). Abnormal lead exposure in globally threatened Cinereous vultures (Aegypius monachus) wintering in South Korea. *Ecotoxicology*, *18*(2), 225-229.

- **(South Korea) A discussion of the scope of the report was added to the objectives and narrowed to the United States. These references were cited in referral to similar circumstances worldwide, but not discussed.**

5. Already list above, but would suggested these are seminal papers that have been omitted: Trinogga, A., Fritsch, G., Hofer, H., & Krone, O. (2013). Are lead-free hunting rifle bullets as effective at killing wildlife as conventional lead bullets? A comparison based on wound size and morphology. *Science of the Total Environment*, *443*, 226-232.

- **Information related to economics, availability, efficacy, user attitudes, etc, are outside the scope of this document.**

Other recent and important papers that may prove seminal:
Johnson, C. K., Kelly, T. R., & Rideout, B. A. (2014). Lead in Ammunition: A Persistent Threat to Health and Conservation. *EcoHealth*, 1-10.

- **Review paper, chose not to include**

Thomas, V. G. (2013). Lead-free hunting rifle ammunition: product availability, price, effectiveness, and role in global wildlife conservation. *Ambio*, *42*(6), 737-745.

- **Information related to economics, availability, efficacy, user attitudes, etc, are outside the scope of this document.**

6. Consideration of the available information on alternate sources of lead has received reasonable coverage in the report. The one area that probably should receive further examination is mining and smelting.

The swan data from the Coeur d'Alene area is cited, but there is also data on a raptor, the osprey. Henny, C. J., Blus, L. J., Hoffman, D. J., Grove, R. A., & Hatfield, J. S. (1991). Lead accumulation and osprey production near a mining site on the Coeur d'Alene River, Idaho. *Archives of Environmental Contamination and Toxicology*, *21*(3), 415-424.

- **A discussion of this paper has been added**

One of the papers by Berglund is cited in the report. Additionally, there are a number of other studies of exposure and effects on birds of lead from mining sources in Europe. Most of this work focuses on passerine species, which are more likely to provide a vector of lead to bird eating raptors or other predators, rather than avian scavengers per se. They do, however, demonstrate movement of lead from mining and smelting sources into wildlife food chains.

- **While these are good examples, we believe the same arguments can be made using the US examples provided.**

Some examples:
Berglund, Å. M., Klaminder, J., & Nyholm, N. E. I. (2008). Effects of reduced lead deposition on pied flycatcher (Ficedula hypoleuca) nestlings: tracing exposure routes using stable lead isotopes. *Environmental science & technology*, *43*(1), 208-213.

Berglund, Å., Sturve, J., Förlin, L., & Nyholm, N. E. I. (2007). Oxidative stress in pied flycatcher (Ficedula hypoleuca) nestlings from metal contaminated environments in northern Sweden. *Environmental research*, *105*(3), 330-339.

Berglund, Å., & Nyholm, N. E. I. (2011). Slow improvements of metal exposure, health-and breeding conditions of pied flycatchers (Ficedula hypoleuca) after decreased industrial heavy metal emissions. *Science of the Total Environment*, *409*(20), 4326-4334.

De Francisco, N., Ruiz Troya, J. D., & Agüera, E. I. (2003). Lead and lead toxicity in domestic and free living birds. *Avian Pathology*, *32*(1), 3-13.

Eeva, T., Belskii, E., Gilyazov, A. S., & Kozlov, M. V. (2012). Pollution impacts on bird population density and species diversity at four non-ferrous smelter sites. *Biological Conservation*, *150*(1), 33-41.

Eeva, T., Lehikoinen, E., & Pohjalainen, T. (1997). Pollution-related variation in food supply and breeding success in two hole-nesting passerines. *Ecology*, *78*(4), 1120-1131.

Eens, M., Pinxten, R., Verheyen, R. F., Blust, R., & Bervoets, L. (1999). Great and blue tits as indicators of heavy metal contamination in terrestrial ecosystems. *Ecotoxicology and Environmental Safety*, *44*(1), 81-85.

Scheifler, R., Coeurdassier, M., Morilhat, C., Bernard, N., Faivre, B., Flicoteaux, P., ... & Badot, P. M. (2006). Lead concentrations in feathers and blood of common blackbirds (Turdus merula) and in earthworms inhabiting unpolluted and moderately polluted urban areas. *Science of the total environment*, *371*(1), 197-205.

- **While these are good examples, we believe the same arguments can be made using the US examples provided.**

7. The overall scientific foundation could be strengthened by broadening the spatial scope of the considered literature and evidence, as outlined above. Big game and 'varmint' hunting occurs across North America as do scavenging birds, and it is likely, therefore, that exposure and poisoning also occurs across the continent, including those jurisdictions where it has not been well documented to date.

- **A discussion of the scope of the report was added to the objectives and narrowed to the United States. Where a reference from outside the US could enhance a general point, it was included, but was not intended to be a comprehensive review of literature outside of the US.**

One option may be to map known concentrations of raptors during fall and winter along with areas of dense hunting activity and look for overlaps, essentially expanding on Figure 9. This could be along the lines of overlays of waterfowl hunting and lead exposure of ducks (Scheuhammer, A.M., Norris, S.L., 1995. A review of the environmental impacts of lead shotshell ammunition and lead fishing weights in Canada. Canadian Wildlife Service Occasional Paper No. 88,Ottawa, Canada.).

- **This is an excellent idea, might be appropriate for a separate, follow-up project.**

Also the parallels with the situation in Germany and elsewhere of eagle and vulture species would enhance the argument that ammunition lead is a significant and wide spread factor reducing survival, and likely reproductive success of birds which scavenge readily on game carcasses.

- **A discussion of the scope of the report was added to the objectives and narrowed to the United States. Where a reference from outside the US could enhance a general point, it was included, but was not intended to be a comprehensive review of literature outside of the US.**

Specific comments:
P 77 – 78 – there seems to be some confounding of blood versus liver lead threshold values. See for example, section 2, L 4-5 – liver versus blood lead concentrations. Similarly, P 78, para 2, L 5 – liver lead?

- **This was corrected from blood to liver**

P 80 – the narrative / paraphrasing of the information from Parish et al 2009 is not well written and should be revised. Why are the last sentences in this paragraph written in the conditional form (“would move”, “would stay”)? Narrate in past tense.

- **This paragraph was revised**

REVIEWER 5

General Comments:

The authors have made a worthy effort in laying out the published facts relating to lead exposure in avian scavengers, and they have done so in a pleasingly organized way. They have cited the key references, although perhaps not always in sufficient depth. An explanation, for example, of what Green et al. 2008 suggested about the implications of multiple exposures comes to mind (more later). I cannot tell to what extent the authors focused on "...an evaluation of the scientific uncertainty," as promised in the Objectives section, and called for six times in the peer group's Scope of Services. The paper contains little of that, presumably because the authors found almost nothing to quibble about. Perhaps it is asking too much of them to detect flaws and contradictions within so large a volume of material, and it might be more to the point were they to devote a section at the end to listing and explaining the gaps in needed knowledge they may have detected during their review. Again, and as a prime example of uncertainty, the incidence of death from single-event exposures versus multiple exposures over time has been largely ignored

in the published literature, and yet the issue is of considerable importance in understanding the epidemiology of lead exposure and death in condor (and eagle) populations and what levels of management are required to sustain them.

All in all, a proper explanation of the pathways and implications of lead exposure to avian scavengers requires knowledge of toxicology, avian life history, behavior, population ecology, and an understanding of firearms and hunting practices. The paper deals best with toxicology, but sometimes a bit more superficially with the other topics. In consideration of the diverse readership of the document that emerges from this exercise and the need for clear communication, I recommend consultation with an avian population ecologist and perhaps an experienced hunter to assist the authors in a revision. This suggestion in no way ignores the depth of the current stage of examination and its clarity of presentation. As good examples of these virtues, I refer to the entire section on "Toxicological Impacts of Lead in Birds" (pages 12-20) and to the first eight lines under the heading "Use of stable isotopes..." on page 53.

Question 1. The Objectives paragraph appears to contain the essential elements one might expect from the title and the purpose of such a document. My job is be picky, however, and alas, I do find the paragraph somewhat indirect and would rearrange it as follows: "The objective of this paper is to gather and review current science on the effects of ingested lead upon scavenging birds and their populations. The document accordingly focuses upon the general toxicity of lead, its bioavailability, physiology of uptake, methods of measuring and evaluating its presence and pathology, exposure pathways, population-level effects, case studies of lead-affected wildlife, other lead sources, alternatives to lead ammunition, and questions regarding scientific uncertainty."

- **The objectives have been restated to better align with the content and intentions of the report.**

Question 2. The first discussion point on page 19 and earlier in the text asserting that lead toxicity in birds is "extremely well understood" is an overstatement. It is quite enough to say "...well understood," and even then, presumptuous. Consider, for example, the ever widening discoveries of lead's sublethal effects upon humans, and from concentrations deemed insignificant only a short while ago. Avian toxicologists have, in comparison, made little progress in exploring the sublethal impacts of lead upon birds and the extent to which those effects influence demography. In mentioning this, I note that the authors quite adequately deal later on with what literature there is on sublethal effects. My point is simply that most of the subject awaits an understanding.

- **Agreed, this statement has been revised**

The last discussion point in the box on page 19 refers to "...specific physiological responses that are measurable, but may vary among individuals and species," and paraphrases an earlier mention of this on page 6 of the Executive Summary. The statement is true but fails to inform the reader of lead's more general nature. The authors delay until page 38 the mention that lead mimics calcium at binding sites, a fact that makes lead so universally pernicious, especially with respect to nerve action. The authors might enlarge a bit upon the wide diversity of lead's human health manifestations, even in very small concentrations, and perhaps make (or refute) the point that avian lead physiology cannot be expected to differ categorically from that of humans. The authors might consider discussing such issues earlier in the document. For Discussion Points, they might consider saying something like "Lead exposure yields a number of specific and measurable responses, but is also largely universal in its effects;" and perhaps "Science is repeatedly discovering new manifestations of its pathology in humans and other species."

- **The discussion on lead's similarity to calcium and the resulting effects has been expanded, and this statement modified to be more explicit.**

Question 3. The authors (on page 75) appear to support the argument that "...anything less than complete removal of lead ammunition from the condor's habitat could result in a high frequency of exposure in the population." That idea was conceived by Green et al. (2004) with respect to Old World vultures threatened by diclofenac, a veterinary compound in livestock carcasses that was shown to be lethal in a single meal. Whereas it is true that single doses of lead can be lethal in condors, the incidence of such outcomes is unknown. Moreover, we now know from blood monitoring that virtually all free-ranging condors are fairly often exposed to lead, and that they usually survive it without intervention. Green et al. (2009) modeled data from the condor population in Arizona and suggested that the condition of multiple exposures over several months was the more likely factor accounting for lethality, and most probable through "....a cumulative effect of protracted high blood lead levels on organ function." I think the authors of the document I am reviewing may have overlooked this possibility when they examined Finkelstein et al. (2012). That paper argued (wrongly, in my opinion) *"...that if only 0.5% Of carcasses are contaminated with lead, the probability that, over 10 y, a condor will feed on a contaminated carcass is still 85–98%. Thus, very low carcass contamination rates are required to avoid high probabilities of lead poisoning* [my emphasis] *within the condor population."* Obviously, the complete elimination of lead-based ammunition would greatly enhance the likelihood of condor recovery and is thus highly desirable, but one must not enlarge the case beyond its factual underpinnings. The authors are to be commended for having not done so (they mention "exposure" rather than "poisoning"), but in the interest of discussing the faults and virtues of the published literature, they might consider making some of these points and at least modifying the one implying the necessity of complete removal quoted in the first sentence of this paragraph. Remember that, diclofenac permeates a carcass whereas ammunition lead is particulate in its distribution, such that a meal does not equate to an exposure.

- **Interesting discussion. We feel that the idea that a small number of carcasses can expose multiple individuals is relevant whether that exposure is lethal or not. And while lead does not permeate a carcass to the extent that diclofenac does, fragmentation of bullets can result in a high percentage of a carcass being contaminated so that in many cases a meal will equate to an exposure. However, in the streamlining of the condor section, we chose to focus on just the extent of exposure to be consistent with other case studies and further discussion was greatly reduced.**

Question 4. Yes, all in all, I believe the authors consulted the best available science, as evidenced within their list of cited references. My concerns mainly focus upon the need for deeper, clearer explanation.

- **No response required**

Question 5. Seminal? I can think of none.

- **No response required**

Question 6. The authors mention the issue of "varmint shooting," but I suggest they expand upon it, as it is common practice throughout the southwest. Lead-based bullets manufactured and advertized for coyotes and other "varmints" are specifically designed to explode upon impact. Coyotes shot with those bullets, for example, often show no exit-wound, and the entire array of hundreds of bullet fragments may therefore remain within the animals. The authors might consider describing these types of bullets and the implications of their use. There are a number of brands, and only slightly modified versions are advertised for big game hunting, with many hunters inappropriately using them for deer and elk.

- **The fragmentation section contains a section devoted to small game/varmints. The bioavailability of these types of bullets gets the same attention as for larger game, as the data allow.**

Some manufacturers mislead users in describing these bullets as exhibiting "controlled expansion," as on the following web page: http://www.nosler.com/ballistic-tip/ The video on that page falsely depicts the bullet as remaining in one piece upon impact. Now take a look at the second row in Table 2 in Grund et al. (2010). I recommend the authors delete the inference on page 33 that one type of "controlled expansion" bullet was relatively safe according to Grund et al. (2010). The term is far too loosely applied by advertisers.

- **The results of the study, in which one of the so-called controlled expansion bullets produced less fragments, were not deleted from the paper. However, the discussion**

was modified for clarity. In addition, the "key point" bullet was deleted – since only two types of bullets marketed this way were tested and one of them produced significant fragmentation, there isn't enough data to draw a general conclusion.

On page 7, the authors mention that "non-expanding bullets" may nevertheless fragment. The reason why they are generally not used in hunting, however, is because, by not "mushrooming," they are inefficient at transferring energy and are therefore less quickly lethal (and therefore less humane). Later on in that paragraph, it should be mentioned that monolithic copper bullets in use today "mushroom" very effectively and are as humane or more so than lead-based bullets in effecting quick kills. Again, to the extent that varmints are left in the field, varmint shooting has the potential of presenting a great deal of consumable lead to scavengers and the matter should be discussed more thoroughly. There are some illuminating radiographs available that could be placed in the report.

- **This sentence on non-expanding bullets was deleted (above previous response)**
- **A brief description of bullet expansion was added.**

I have not seen clear evidence that ground squirrel and jackrabbit shooting is an important factor in condor lead exposure, but the activity is commonplace in some parts of the condor range, as is coyote shooting. After mentioning a list of hunted taxa on page 74, the authors follow (top of page 75) with a statement about the volunteer lead abatement program in Arizona as mitigating, but they should also mention that the program applies only to ungulates.

- **This point was clarified in text**

Question 7. Yes, the overall scientific foundation is reasonable.

The authors might explain (and early on) the several levels of impact that lead-caused mortality and morbidity can inflict upon scavenger populations. The first is population inviability, a condition that would characterize lead's effect on the California condor in the absence of periodic releases, blood-lead monitoring, and treatment. The second is instability in which the additive effects of each morality agent and reproductive impairment render populations of territorial species (e.g., eagles) less secure by reducing non-breeder reserves (floaters). The third is sublethal impairment of individuals, a topic which authors capably reviewed.

- **A brief, general section on demographics was added**

Along these lines, the report should also explain that condor and eagle populations are far more sensitive to adult deaths than to deaths of younger birds, and that while some mortality agents disproportionately affect the younger age categories, others are indiscriminate in killing older

birds. As it is, the authors (and others) lump the deaths of young and old condors in their reporting, an obscuration that understates the significance of lead poisoning. See, for example, pages 76 and 77.

- **A brief, general section on demographics was added**

On the top of page 35, I observe that "0.01 - 17.21 mg" is not a concentration.

- **corrected**

The authors wait until page 80 to mention depuration and the short half-life of lead in condor blood, a factor that makes blood lead level measurements usually unreliable in assessing the degree of exposure. The reader needs such understanding to evaluate Table 1 and information on blood lead levels and threshold values throughout. I recommend a much earlier explanation.

- **Agreed, this information is presented prior to the discussion of blood monitoring in condors**

Another point that should be made is that hunters normally target the thorax of large animals, and that is why offal piles usually contain many fragments. Hunt et al. (2006) found that 50% of 20 deer offal piles in their sample contained over 100 fragments.

- **The extent of fragments in offal piles was reported but we did include a discussion of hunting techniques.**

Near the top of page 26, the authors seem (mildly) to suggest that varmint shooting is relatively uncommon. Varmint shooting can, in fact, be widespread and intense in regions inhabited by condors and golden eagles and likely represents a significant source of lead to these species, especially considering the highly fragmenting bullets often used for such purposes.

- **This statement was modified to be more consistent with statements made in condor section concerning regional popularity of varmint hunting**

On pages 77 and 78, the authors allude to chelation therapy as a cause of visceral gout and death, but they do not explain that the injurious therapy was of a particular type, an oral succimer treatment which is no longer in use, or has been revised. Conflating standard chelation injections with oral succimer is therefore misleading.

- **References to visceral gout were removed**

The assertion on page 78 that condor death in Arizona resulted from chelation therapy is false; the succimer treatment was never applied in Arizona.

- **The sentence did not mean to imply that chelation resulted in death, the statement was reworded.**

Moreover, the statement on line 5 of the first paragraph on page 78 to the effect that five condors had blood levels below the threshold level for toxicosis at the point of death is also misleading in consideration that chelation reduces blood lead levels.

- **It was meant to read that the blood levels were expected to be low because of the chelation therapy; reworded for clarity.**

Lastly is the issue of the blood lead levels themselves. On page 78, 1st paragraph, there is the parenthetical "...all under 5.2 ppm wet weight," which equates to a whopping 520 micrograms per deciliter (also note the 3.2 ppm in the blood on the previous page). And wet weight for a blood lead level? The sentence (and paragraph, and indeed, almost the entire condor section except for the last paragraph) is fraught with ambiguity.

- **Corrected from blood to liver**

Explaining the implications of additive mortality to the population dynamics of raptors and other scavengers would fit nicely with the objectives of this document.

- **A brief, general section on demographics was added but more in-depth topics of population dynamics are beyond the scope of the objectives.**

I may have missed this, but the authors might mention the idea that scavengers of ungulates and other large mammals may not encounter enough calcium to adequately compete with lead for binding sites. Would not bone calcium be generally less available to scavengers of large mammals than of small ones? Also scavengers of large mammals may ingest less hair than scavengers of small mammals, making it less likely that lead would be bound and regurgitated in a pellet.

- **Interesting suggestions though we did find a discussion of this in the literature to refute or confirm this theory.**

To hunters, the term "upland game" normally applies to hunted birds other than waterfowl. The authors tend throughout to confuse it with big game hunting, small game hunting (e.g., rabbits), and varmint shooting.

- **Terms were clarified throughout the document.**

In the second-to-last sentence of the first paragraph on page 57, the phrase beginning with "...rises in isotopic ratios" could be struck. Environmental ambience would not produce a spike of 50-90 ppm, although I might have misunderstood.

- **Concentrations in the feather spiked to 50 ppm in the rachis and 90 ppm in the vane. The text was edited to clarify that it wasn't an additional 50- 90 ppm spike.**

The authors should mention that, among condors that have simply disappeared and have not been resighted, it is likely that some proportion have died of lead poisoning, meaning that current knowledge of the incidence of lead-related death is an underestimate.

- **This is a valid point. However, this section was shortened no longer addresses causes of death or disappearance other than lead.**

The authors might mention the increase of surface-area (available to stomach acids) with increased fragmentation in the section on "Physiology of raptors and scavenging birds."

- **Added to fragmentation section**

Bullet fragments radiate rather than migrate from wound channels (see pages 7, 30, 32, 33, 37).

- **modified**

At the bottom of page 69 and elsewhere, the authors point out that not all lead-poisoned bald eagles are found and collected. They later mention that bald eagles are conspicuous (often associated with water bodies), and that increases the chance that fatalities or moribund birds will be found. They might also mention somewhere the obvious fact that stricken golden eagles are unlikely to be detected within the vast landscapes they inhabit, and that their rates of mortality and morbidity from lead ingestion may also be high, considering their affinity for carrion. The point is that mortality rates for bald eagles may not be "...increased" or in any way unique, as suggested in Discussion Point 1 at the bottom of page 70.

- **Modified that this is not relative to other scavengers**

On the bottom of page 73 in the second-to-last paragraph, we see "Microtrash ingestion, predation, depredation, and exposure to DDT/DDE in the coastal population provide additional mortality events." How is "depredation" a "mortality event?" Indeed, a review of the four times in the ms (pages 10, 73, 75, and 81) that the word "depredation" appears suggests that the authors may be uncertain as to its meaning. Also, DDT/DDE is best classed as a reproductive impairment rather than a mortality factor. I suppose an embryo is a life stage subject to mortality, but it does not figure as such in standard demographic analysis. Sperm, for example, is also a mortal life stage. The authors might better end with "...impact vital rates."

- **This section was removed and the focus was limited to lead as a cause of mortality.**

Figure 3 (page 31) does not appear to be an offal pile, although it might be a small portion of one (wrapped in paper?). Note the distinct margins and the size of the fragments relative to the entire image. An informed reader would be skeptical, so perhaps more information is needed as to what the photo actually represents.

- **We re-confirmed with the picture's source and it is indeed an offal pile.**

The section that begins on the bottom of page 73 and continues into page 75 presents a series of non-sequiturs that do not fulfill the expectation of the condor's "unique" susceptibility to lead ammunition. I suggest a tightening of that section.

- **This section has been revised**

Unless I missed it, the authors might also somewhere explain that the most important contributor to condor population vulnerability is the condor's protracted maturation, its very slow rate of reproduction, and its consequent high sensitivity to mortality among the older age classes. This is not to say that other characteristics aren't also predisposing, but the very low natural demographic potential of condor populations is the most powerful issue in their vulnerability to lead, indiscriminate, as it is, with respect to condor age.

- **A brief, general section on demographics was added**

Regarding the 207Pb:206Pb ratios (page 54 and 55) in ammunition lead on which Church et al. (2006) based their conclusions, subsequent analysis of a larger sample of bullets (showing far wider ratios) undermine their conclusions. The authors cite Finkelstein et al. 2012 when mentioning the wider ratios ("0.78-0.87"), but I cannot find that information in the PNAS paper or in its supplementary information. The authors do not directly speak of the implications of that uncertainty, although in the Discussions Points (page 58) they quite appropriately avoid placing any weight upon the idea that Pb ratios provide an ammunition signature. No complaints here, only that I cannot find the referenced data in the citation.

- **This information is from Figure 3 of the Finkelstein paper.**

Reviewer 5 comments in the document
Note: Minor/editorial comments from the reviewer are italicized and were addressed in the revision as appropriate

- Is it possible to predate a carcass? I recommend "...predation. or of scavenging the remains of animals killed with ..." That way one includes offal piles in the mix.
    - **revised**
- Consider explaining here that lead has binding properties similar to calcium and therefore has multiple deleterious effects, etc..yet it nevertheless
    - **added**
- *produces some "...specific physiological responses that are measurable..."*

Page 7

- *Consider "...encouraged the development and approval of ..."*
- *Should be "...bullet fragments"*
- *"...animals that are..."*
- *containing*
- *bullet fragments*
- *some scavenger species*
- *shotgun pellets*
- *radiate*
- Non-expanding bullets are generally undesirable for hunting because they are less lethal and therefore less humane.
    - **This sentence was removed due to reflect revisions in the body of the report.**

Page: 8

- *"...or prior regurgitation, elimination, or complete..."*
- *Many*
- *have included*
- *"...ammunition projectiles..."*
- *indicative or suggestive*
- *bullet fragments*
- *shotgun pellets*

Page: 9

- *transitioning*
- *Serial*
- *...along the length of feathers...*
- *omit*
- *temporal changes*
- *Numerous other sources*
- *"...make hunting ammunition a more likely source, and..."*
- *region*
- *True, but better to say "....killed by guns..." Hunters aren't the only ones who shoot animals. Hunting is a mode of foraging. "Varmint-shooters" are not hunters, for example.*

- *replace comma with semicolon, or (better) begin the first sentence with "Whereas.."*
- *fatalities; Just because almost everyone else uses a word that isn't in the dictionary doesn't make it correct.*
- *free-flying*
- *Some of the remaining 52% likely had such concentrations but were not tested at the time of involvement. Consider placing "at least" before "48%" or replacing "had" with "showed."*

Page: 10

- *projectiles*
- *is nontoxic.*
- *most popular*
- *local threats*
- *scavenging and preying upon*

Page: 11

- *reduced*
- *comma*
- *Insert a comma when you change subjects. Otherwise the reader may have to pause to make sense of what you are trying to say.*
- *This is an awful sentence.*
- *ammunition-lead exposure*
- *Should be "...effects upon..."*
- *Why not just say "adversely affected?"*
- Implies that species have been endangered for over a century. While true, it could be quibbled with. Why not say "....has adversely affected native birds for over a century, and now threatens at least one endangered species."
    - **revised**

Page: 12

- Should read "...predation. or of scavenging the remains of animals killed with ..." That way one includes offal piles in the mix.
    - **revised**
- *comma*
- *of waterfowl*
- I would also cite Anderson et al 2000 here.
    - **Added ref**
- *omit*
- *comma*

Page: 13

- Consider saying this sooner in the document.
    - **Agree, this is now mentioned in the Introduction.**
- *Don't forget to add a comma when you change subjects.*

Page: 15

- *...even though...*

Page: 16

- *Consider replacing with "remain"*

Page: 17

- You explain the reason on page 55, but mentioning it here seems out of place and leaves the reader in the dark. You could say ..." (see page 55)..."
    - **More information was added**
- *than*

Page: 18

- *Replace with "...fatalities..."*

Page: 19

- *omit*
- Lead yields a number of measurable responses, but it is also somewhat universal and unpredictable in its effects. Science repeatedly discovers new avenues of its pathology.
    - **This sentence was revised**

Page: 20

- *on*
- *lead-dosed*
- *hunter-shot*

Page: 22

- *nontoxic shot development ceases*
- *shot-use*

Page: 23

- Not sure what is meant here.
    - **revised**
- with an estimated 1.4 million
    - **revised**

Page: 24

- *because of*
- *omit*

- Consider mentioning the complication of fishing weights as a source of lead to swans.
    - **Fishing lures are covered in Alternate Sources of Lead**
- By what pathway? Eating a dead bird with pellets in GI track?
    - **revised**

Page: 25

- "*...settlement, from subsistence..."*
- *comma needed with change of subjects*
- *to*
- *...quickly and therefore humanely kill...*
- *omit*
- ...projectile expanding in diameter when it strikes the animal. Because lead is highly frangible, it also tends to fragment into smaller...
    - **revised**
- Consider citing STROUD, R. K., AND W. G. HUNT. 2009. Gunshot wounds: A source of lead in the environment. In R. T. Watson, M. Fuller, M. Pokras, and W. G. Hunt (Eds.). Ingestion of Lead from Spent Ammunition: Implications for Wildlife and Humans. The Peregrine Fund, Boise, Idaho, USA. DOI 10.4080/ilsa.2009.0109
- *through*
- *not yet widely*

Page: 26

- omit as somewhat misleading. Varmint shooting is rampant in some regions.
    - **revised**
- *omit or repair grammar*
- *animals that are*
- *and*
- *omit*
- *and offal*

Page: 27

- Delete sentence as irrelevant.
    - **Left in as important to acknowledge, but revised to enhance relevance**
- ..., although the diet of latter may include a high proportion of plant material (Kirk et al. 1998). See Appendix 1 in Kirk, David A. and Michael J. Mossman. 1998. Turkey Vulture (Cathartes aura), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: -
    - **revised to include**
- and golden
    - **revised**

Page: 28

- why so?
    - **? not explained in paper**

Page: 30

- Bald eagles aren't exclusively carrion-eaters, but are at relatively high risk. Consider deleting sentence.
    - **Agree – considering evidence of shifting diets during hunting season, etc, part-time carrion eaters may be at equally high risk. Sentence deleted.**
- *radiate*

Page: 31

- The image is way too small to be an offal pile. Is it a meat package?
    - **Confirmed that this is indeed an offal pile**
- That fragment in the upper right-hand corner does not look like an intact jacket, but rather a piece of it. That would mean that some of the 107 pieces were copper. You could say "...which fragmented into pieces, 107 of which were in the offal pile. Or simply say "The bullet fragmented, and 107 pieces were distributed within the offal pile. Lastly, that photo doesn't look like a meat package, not a gut pile. Look at the edges.
    - **Confirmed that the text is correct as written**

Page: 32

- *Revise to "...the spent remains of the copper jacket and fragmented lead core of a lead-based bullet (left) compared with a copper (lead-free)*
- *expanding bullet that remained intact, as is typical.*
- *Several experimental studies of bullet fragmentation in large game and examination of gun-killed carcasses and offal piles showed...*
- *Fragment samples ranged in...*

Page: 33

- *...in total*
- *...one shotgun slug and...*
- *two from muzzle-loaders*
- *Do you mean 0 - 127 fragments?*
- *?????*
- This suggests that all copper bullets produced at least one fragment which is inconsistent with other studies. I think Grund et al. must have counted intact bullets as single fragments.
    - **No, this is correct as written. The study's primary author, Marret Grund, responded to a clarifying question on the topic as follows:**
        - All of these bullets are being fired from weapons with so much energy that the main part of the bullet would always pass entirely through the thoracic cavity of a mid-sized game mammal at 50 meters. I would expect that the main part of

the bullet would pass entirely through the thoracic cavity even at 400 yards when fired by a 308 Winchester which is well beyond the distance a typical hunter could place a bullet into the thoracic cavity of a mid-sized game mammal. So in Table 2, copper bullets had a mean of 2 fragments and a min and max of 1 and 4 fragments. Typically we would observe just a few large pieces of metal with the copper bullets but the lead bullets designed to expand rapidly would produce "dust-like" lead particles that were so abundant and small that they were difficult to count.

Page: 34

- *....at least 15 cm...*
- *...at least...*

Page: 35

- *and*
- *higher-than-trace*
- *...lead bullets (all of the same brand, caliber, and bullet weight) during the...*
- *...processed, each at a separate facility (Hunt et...*

Page: 36

- *omit*
- *has*

Page: 37

- *...non-expanding lead-based bullets....*
- *radiate*
- *containing*
- *hold*
- *produce*
- *...in the...*

Page: 38

- Consider mentioning and explaining this earlier in the document. That will make it easier for the reader to understand the basic problem with lead. Explain that lead substitutes for calcium, and that is why lead has so many manifestations..
    - **Agree, this is now mentioned all the way in the Introduction.**

Page: 39

- Note that the vultures were fed whole chickens and the condors were fed "cubed chicken breast. Does this mean the condors were starved for calcium?
    - **In both studies, birds were fed cubed chicken breast for 2 weeks prior to dosing.**

Page: 42

- *>2*
- *necrosis?*

Page: 43

- also by the weighing of pellets before and after passing through the digestive systems of experimental animals.
    - **Yes, revised to include**
- Might want to include exposure in ere because the section largely deals with it.
    - **Title was revised**

Page: 44

- *Also, in warm weather, blow flies may quickly invade the body cavity through the mouth and destroy organs necessary for diagnosis.*
- *...is largely incidental and generally believed to...*

Page: 45

- Consider citing Parish et al 2009
    - **cited**
- Consider also Bloom et al 1989
    - **Pre-ban, not cited**

Page: 46

- *fatalities*
- *blood lead*
- *omit*

Page: 47

- *clinical*
- *That's nearly a background value according to the table on page 18.*
- *took*

Page: 48

- *additional*
- *omit*
- This is understated and omits comparisons of lead levels in and out of hunting seasons.
    - **revised and moved to Association of Lead Exposure to Ammunition section**
- *shotgun pellets or bullet fragments*
- *The incidental nature of documented....*
- *...must necessarily...*

Page: 49

- *omit*

- *semicolon*
- *hypothesized*

Page: 50

- *comma or semicolon*
- *comma, or semicolon without the "and"*
- *continued*
- *are present*
- *that*

Page: 51

- *suspected*
- *metal*

Page: 53

- *or*
- *various*

Page: 54

- *particular or*
- *Whereas*

Page: 55

- *approach*

Page: 57

- *fatalities*
- *corresponded*

Page: 58

- *snow-fed*
- *feathers*

Page: 59

- Ammunition manufacturers say that they get their lead in batches from any source they can. One cannot therefore rule out ammunition lead when ratios do not corresponded with those of tested samples.
    - **Noted but does not necessarily change the conclusion. Might have to consider that the change in the source of lead may be a different source of ammunition if the circumstances suggest it.**

Page: 60

- *were*

- *unlike*
- *geographical difference*
- foraging range and trash density and distribution.
    - **revised**
- A misinterpretation. Provisioning is year round at the release site. The point that Walters et al were trying to make is that AZ pairs nest in remote circumstances, far from human influence, i.e., trash.
    - **This was how Walters et al described it in text. However, the hypothesis itself did not add to the discussion, so it was struck to avoid confusion/dikstraction.**
- This was Mee's speculation and doesn't need to be elevated to a general belief.
    - **This was struck from report, see comment above**

Page: 61

- *was*
- *somewhat unique*

Page: 62

- Awkward sentence
    - **revised**
- A weakly stated interpretation. Consider saying simply that frequent exposure to lead-based paint appears implausible in consideration of known behavior and ranging data.
    - **modified**
- *omit*
- *omit*
- *southeastern*
- *suggests solubility*
- *best known*
- *in*
- *ingesting lead-contaminated*
- *hyphen*
- *This is opaque. omit?*
- Unclear. ...an additional?
    - **Yes, an additional 7%, corrected.**
- *omit*
- *semicolon*

Page: 63

- *...River Basin. He compared a reference area....*
- *omit*
- *omit*
- *...a reference site and at a contaminated...*

- What pathways?
    - **Ingestion of birds or small mammals, as stated in sentence**
- Mention what is known of the occurrence of lead mines in the condor range?
    - **Prefer not to get that specific, would need to do this for scavengers across the country**

Page: 64

- *were*
- *semicolon*
- Ambiguous pronoun
    - **revised**

Page: 65

- *colon*

Page: 66

- *comma*
- *comma*

Page: 67

- *omit*
- *omit*
- *deer carrion*
- *Among*
- *"...castings (regurgitated pellets of indigestible material)...*

Page: 68

- *Is there a difference between fragments and particles?*
- *projectiles*
- *"...Great Lakes region..." and move to the end of the sentence.*
- *...having blood-lead concentrations consistent with...*
- *during*
- *comma*
- *comma*
- *omit*
- *omit*

Page: 69

- *hyphen*
- That's most of the year. In the absence of a seasonal component, one would expect that most would be found during September and April.
    - **The author's point was to establish the overlap with the hunting season**

- *consider breaking into two sentences*
- *comma*
- *date-of-death*
- Again, what would be the expected distribution in the absence of a hunting season effect?
    - **This would vary by state and associated hunting seasons.**
- *a*
- *comma*
- *comma*
- *e.g.,*

Page: 70

- hyphen
- ...USFWS 2009 (Table C3, page 143)...
- Are all considered anthopogenic?
- What does this mean?
- Please define.
- Can't find where Ferrer et al 1991 mentions a lower maximum..
- lost?
- But haven't you said that much of the winter population is migratory?
    - **This entire section was deemed outside the scope of the objectives and deleted in revision.**

Page: 71

- *makes*
- *omit*
- *association*
- The value was 28%, so just say "...over one-quarter..." Still, what about the wintering component of the at-risk population?
    - **this statement was deleted in revision**
- *omit*
- *comma*
- *omit*
- *probable*
- *....treatment with chelation therapy...*
- *omit*
- *surpasses*
- *hyphen*

Page: 72

- omit
- replace "and" with a comma

- wild-produced
- Untrue. The free-flying population in AZ grows, but only because of continuing releases.
- A contradiction of the last sentence unless you fix it.
- first releases
- 7
- hyphen
- survive from all projects
- space
    - **The condor case study was streamlined in revision and this section removed.**

Page: 73

- one word
- downlisting
- comma
- cause being lead-exposure
- condors
    - **The condor case study was streamlined in revision and this section removed.**

Page: 74

- *and*
- *completely?*
- *implicated?*
- *...the remains of gun-killed animals...*
- *omit.*
- *Elk are tule elk in California and Rocky Mountain elk in Arizona.*
- *consume*
- *ground squirrels, rabbits, and coyotes*
- *omit*
- *Consider the Kaibab forest in Arizona, for example.*
- *...California, for example, can be...*
- *and offal*
- *Ammunition lead exists in many of these remains.*

Page: 75

- *through*
- The train of this paragraph sounds as though the authors are suggesting that the Arizona volunteer program includes varmint shooting. It does not.
    - **clarified**
- *a program similar to that in Arizona.*
- *control*

- Citing Green et al 2004 here is a stretch. Those guys were writing about a contaminant that permeates the entire carcass and is single-doselethal. I think the argument for complete elimination is shaky. It assumes that a single dose of lead is more lethal than has been demonstrated. This is not to say that single doses cannot be lethal or that complete elimination is undesirable, but rather that supporting evidence is unavailable. See Green et al. 2008
    - **The condor case study was streamlined in revision and this section removed to better fit with objectives.**
- ??????????????????
    - **This paragraph removed, but yes, should have been low pH**
- *During that period*
- *...maximum population-at-risk...*
- *omit*

Page: 76

- *fatalities*
- *an ascribable*
- *...juveniles and older birds...*
- *Sentence break needed here*
- *pellets*

Page: 77

- *from*
- *are*

Page: 78

- That diagnoses is incorrect. The succimer treatment (which caused death) was used in California but never in Arizona.
    - **Not the intended meaning of sentence, modified for clarification**
- *are*
- *Did you inquire?*
- I would suspect a carcass to be ignorant of everything.
    - **The Baja reference was deleted, outside designated scope of report.**
- *You are going to have to work on this sentence.*
- *comma*
- *comma*
- *(You need to supply commas where you change subjects.)*
- *comma*
- *...in the southwest...*
- *Please define the southwest population somewhere.*

Page: 79

- *....those measured in samples of known...*
- *The answer is 0.2 ppm.:; Did you ask Chris Parish?*
- *had been*
- *monitored*
- *Rearranging this sentence would make it more readable.*

Page: 80

- *This entire paragraph is a mess.*
- These points need to be made very early in this document to give the unenlightened reader an understanding of what reported blood levels do and do not mean.
    - **Agreed, these points were moved to the top of the condor case study**
- *Fry and Maurer 2003*
- *comma*
- *Specifically*
- *omit*
- *...such that...*
- *can be based*
- *comma*
- *wild-produced*
- *....carcasses, and these include*
- *...carcasses and offal piles...*

Page: 81

- *above*
- *determine*

Page: 82

- and species that consume waterfowl
    - **revised**

Page: 83

- zinc chromate
    - **yes, this was corrected (and on our website as well)**

Page: 86

- ...found copper concentrations of over 1000 ppm wet weight in the livers of...
    - **revised**
- ...lead ban for waterfowl hunting...
    - **revised**

Page: 87

- *omit*

- *One must hunt for the subject of this verb.*