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science for a changing world

Lead exposure and poisoning of wildlife

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Lead – the basics

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Lead in society

- Mined for >6,000 years
- Well suited to casting – low melting point, malleable, corrosion resistant

Wolfgang Sauber, CC1.0


Paolo Neo
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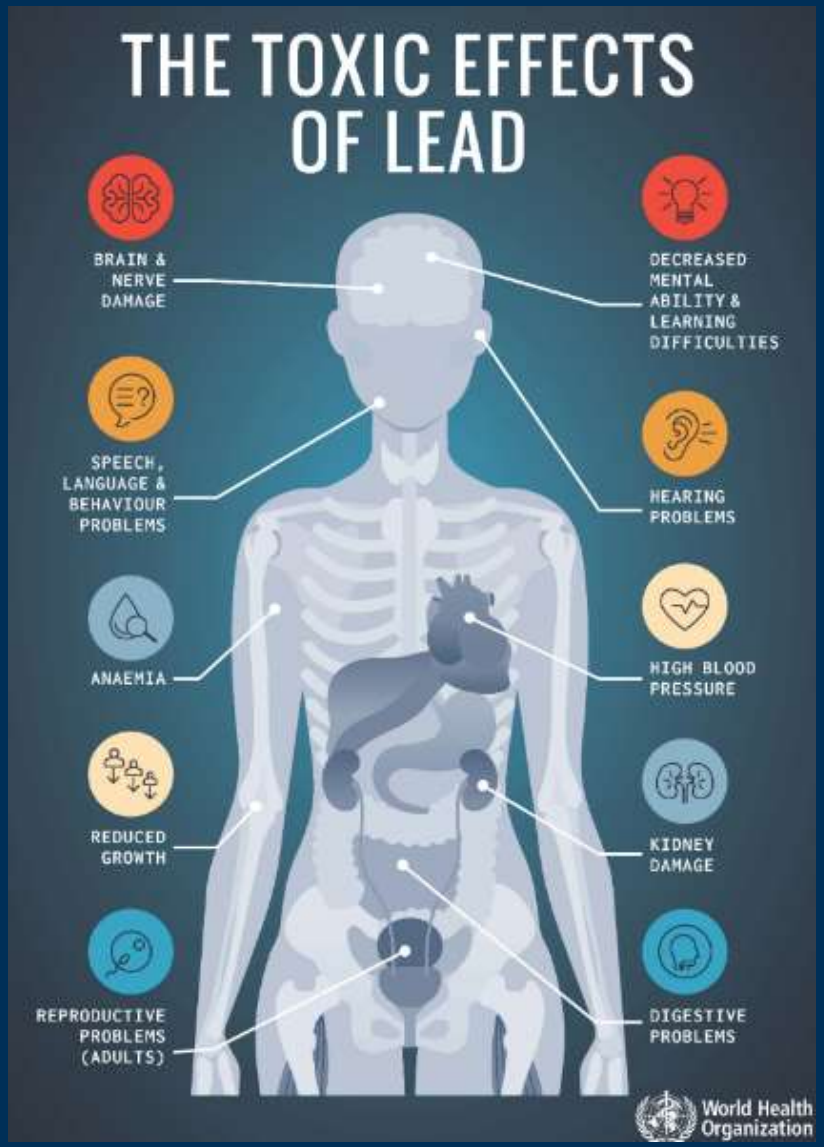
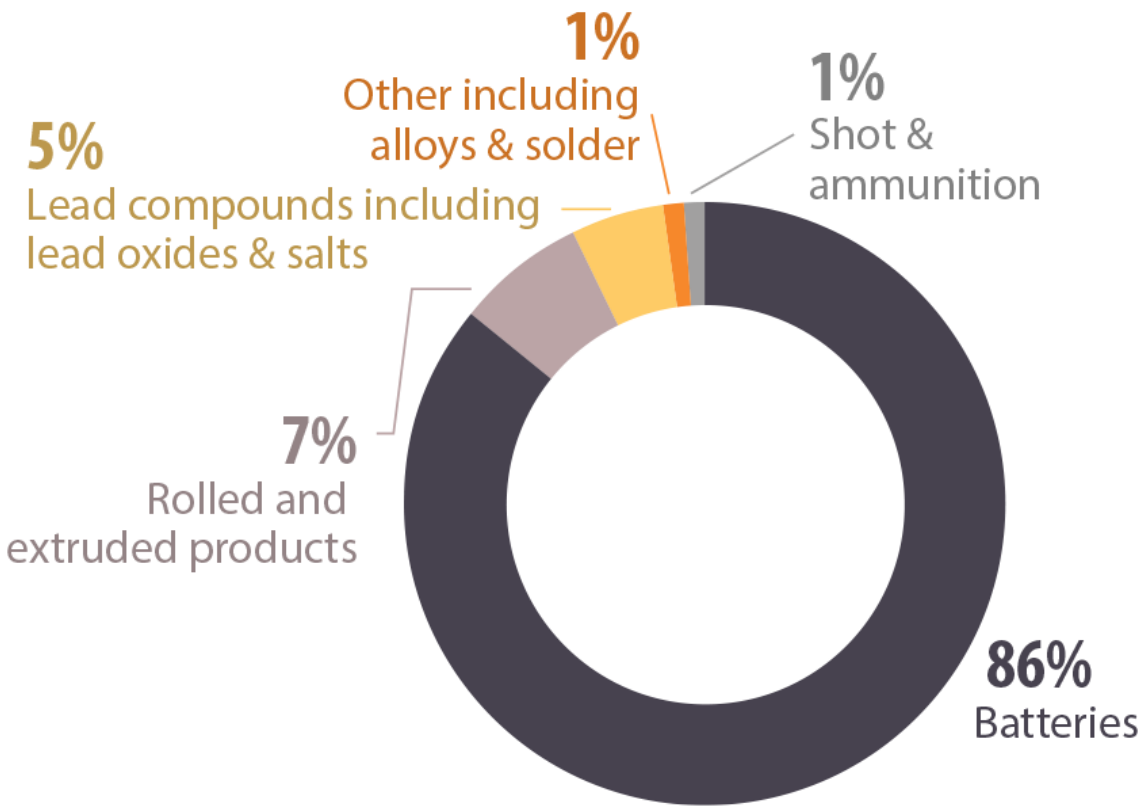
Lead physiology

- Nervous, metabolic toxicant
- No biological role
- No safe level
  - Broad impacts
  - Replaces essential nutrients
    - Interferes with enzyme function

The Raptor Center,
St. Paul MN
(public domain)



Uses of lead worldwide



https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/lead-facts/20518

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How does lead get into wildlife?

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Broad pathways of lead exposure

- Pb is available because of human activity

- Water ➡ wildlife, plants, sediment
- Air ➡ soil, water, and wildlife
- Soil ➡ earthworms, benthic fish, ground squirrels
- Vegetation ➡ herbivores, waterbirds
- Metallic Pb ➡ scavengers, predators, gamebirds, waterbirds

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Detailed pathways of lead exposure

- air, water, food, soil
  - ingestion, inhalation
  - many species
  - *Blanco et al. 2003, Kålås et al. 2000, Santiago et al. 1998*
- lead paint
  - ingestion
  - condors, seabirds
  - observational & isotopic data
  - *Finkelstein et al. 2003, 2012*

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Detailed pathways of lead exposure

- fishing tackle
  - ingestion
  - loon, osprey, bald eagle
  - *Franson et al. 2003,*

  Rattner et al. 2009, Haig et al. 2014
- shotgun pellets
  - ingestion, wounding
  - waterfowl, game birds

  & their predators
  - *Kendall et al. 1996*

- rifle bullets
  - ingestion by avian scavengers
  - hunting, recreational shooting, predator control
  - seasonality, isotopes, pre- vs post- outreach, bullet fragments
  - *Green et al. 2008, Bedrosian et al. 2012, Golden et al. 2015, Slabe et al. 2022*

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Fishing tackle

- Common loon

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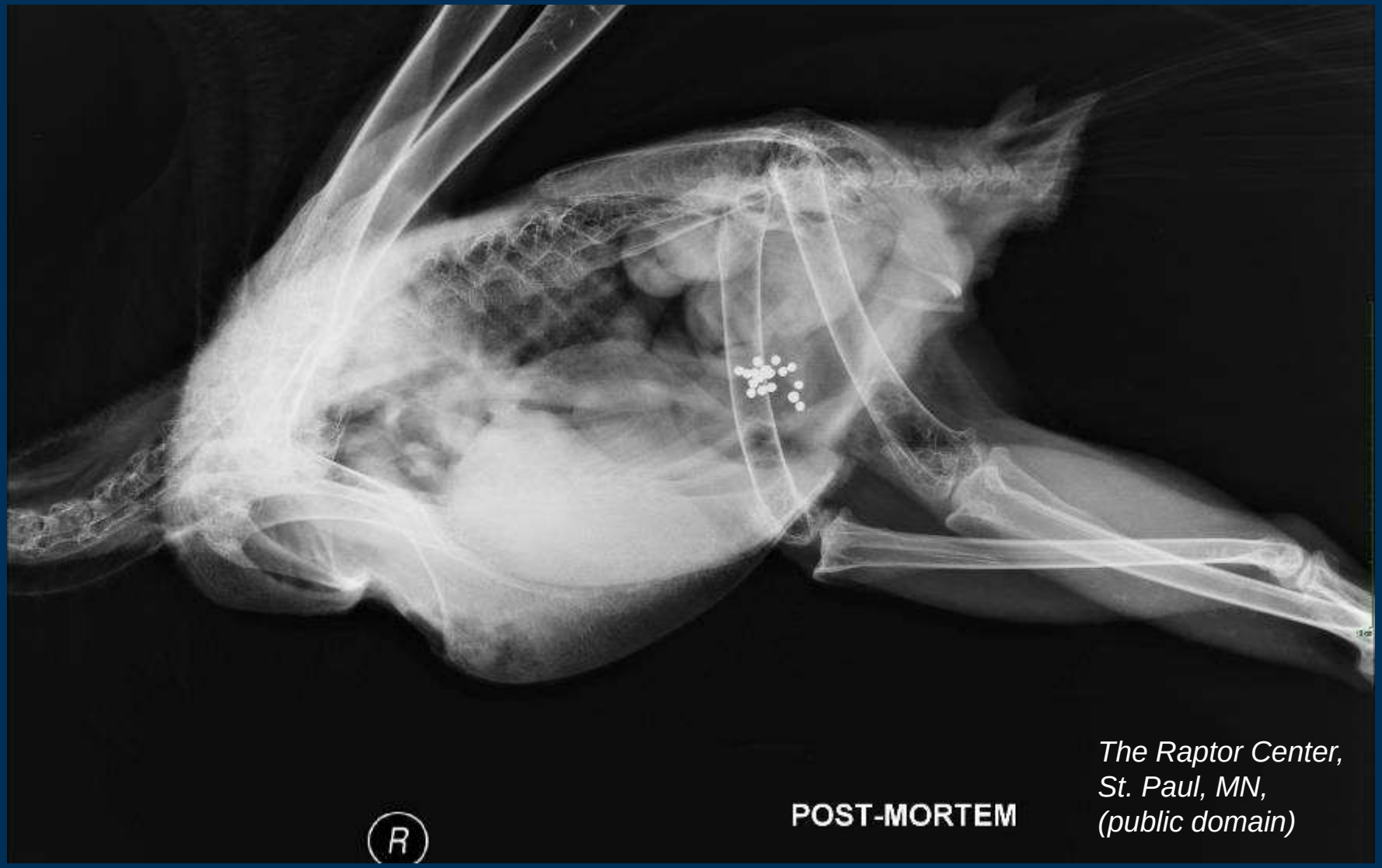
Used with permission,
Mark Pokras, Tufts University

Shotgun pellets

- Bald eagle



The Raptor Center, St. Paul, MN, (public domain)

Rifle bullets

Mike McTee
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Rifle bullets

- Bald eagle

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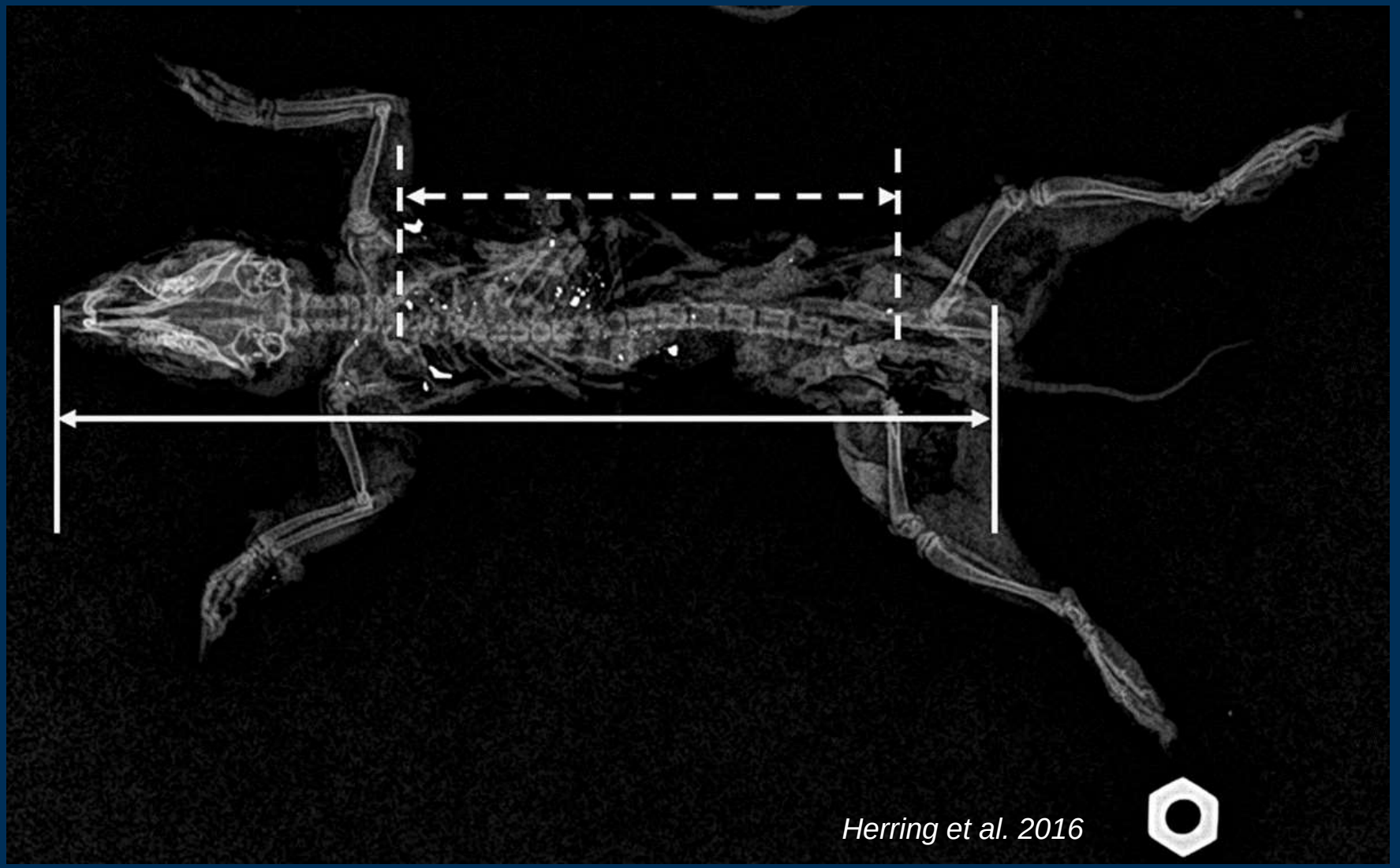
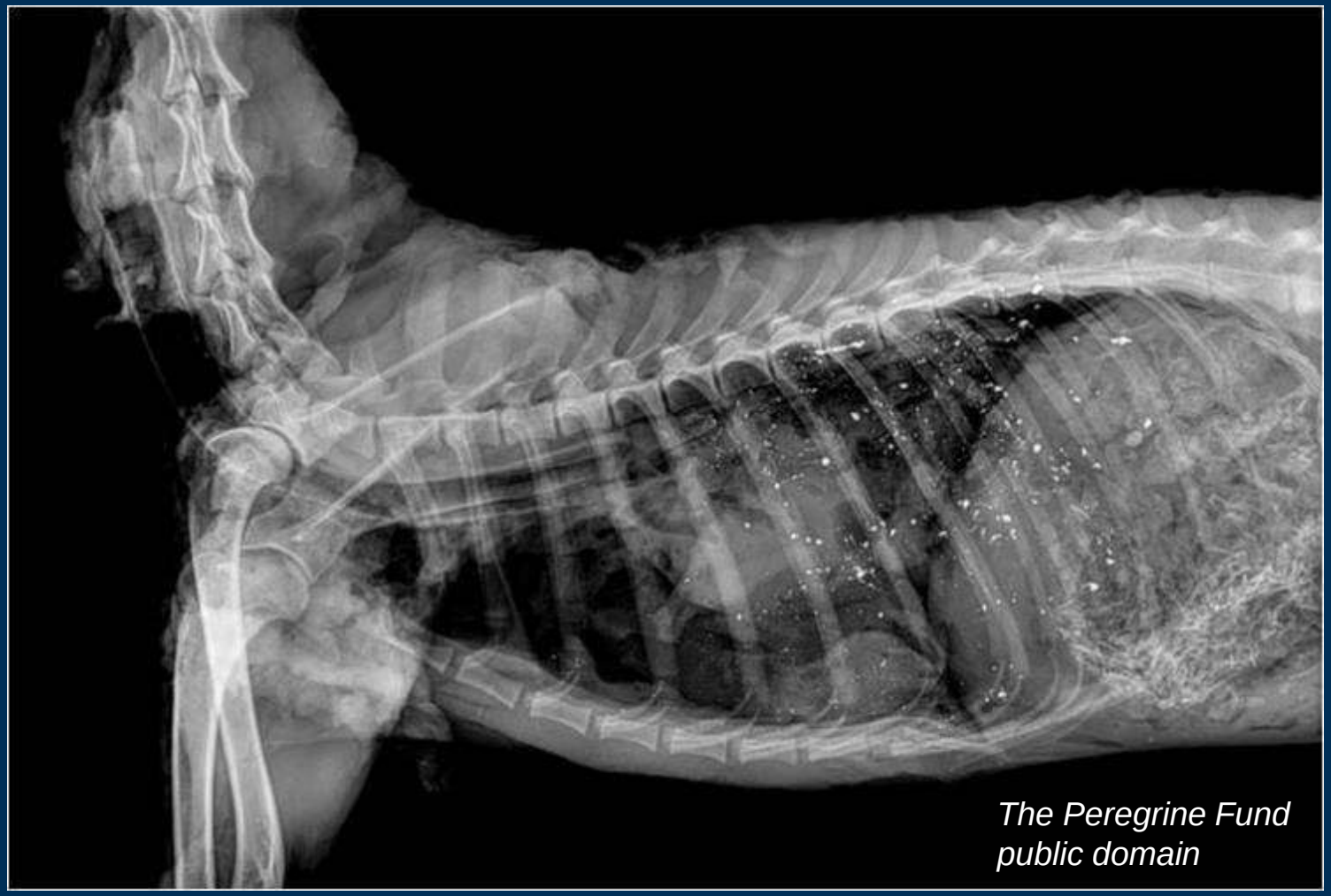
Rifle bullets

- Ground squirrels



Rifle bullets

- Deer



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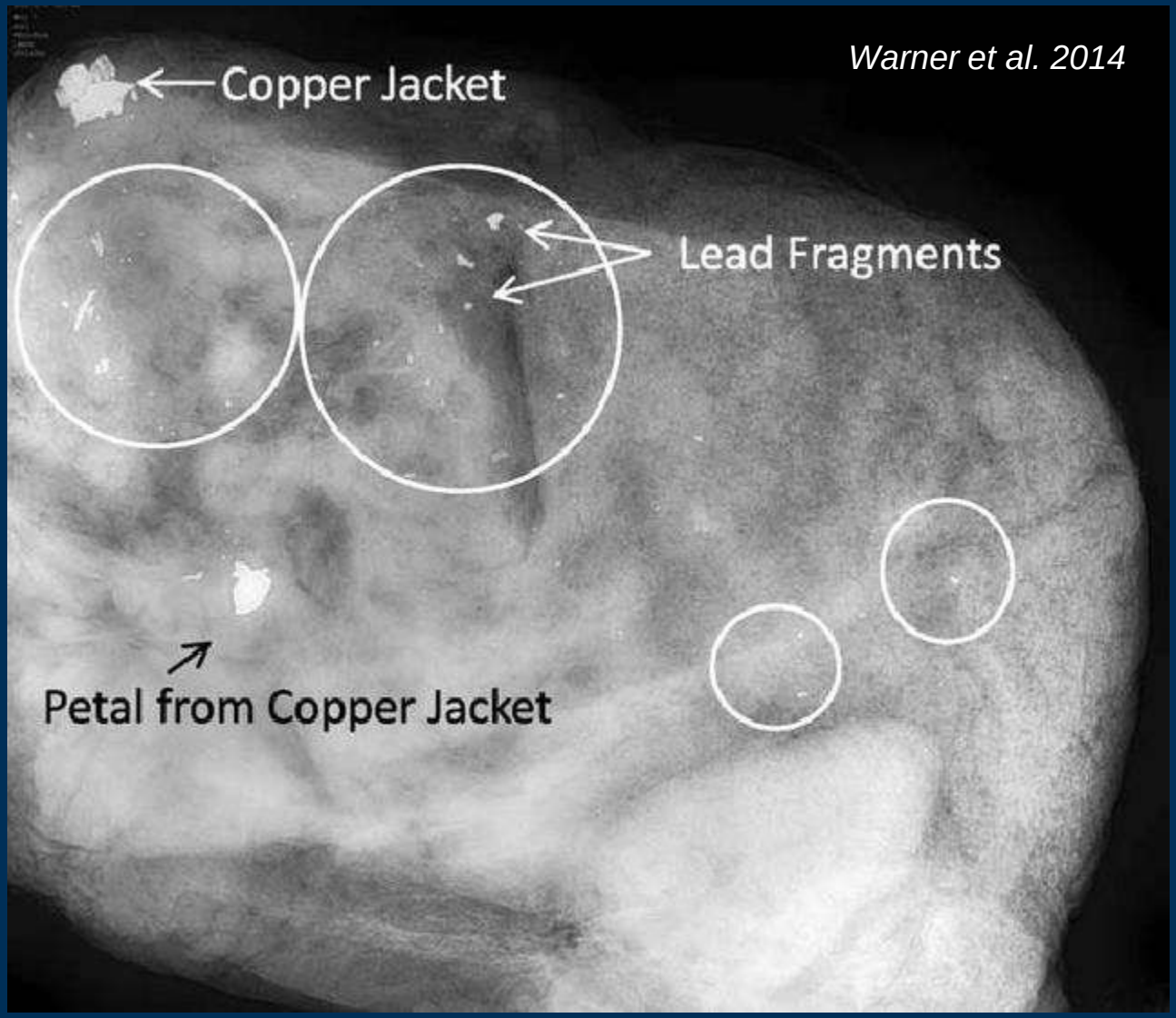
Muzzleloader / shotgun slug

- Offal – white-tailed deer



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Scale of the problem?

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The numbers - shotgun

- Lead banned for waterfowl hunting - 1992
  - ~1.5-2.5 million waterfowl/year died from lead

- 3.7 billion pellets/ha (NJ skeet)
- 8,000 - 860,000 pellets/ha (upland game areas)
- ~6-9 million kg lead/yr (dove hunting, 1980s)

  - *Kendall et al. 1996*

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The numbers – fishing tackle & rifles

- 1 ton lead tackle lost/yr (5 lakes, MN)
- 0.01 – 0.47 sinkers/m^2 (lakes, VT/NY)
- 0.84 – 16.3 sinkers/m^2 (Thames River, UK)
  - *Haig et al. 2014*

- Many thousands of big game taken annually
- 1.5 million prairie dogs shot (2011, SD)
  - *Huxoll 2011*

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Taxa exposed

- Mammals and reptiles
  - multiple experimental studies
  - fewer studies on wild animals
    - grizzly bears *(Fuchs et al. 2021)*
    - red deer *(Reglero et al. 2008)*
    - turtles *(Bishop et al. 2010, Overmann & Krajicek 1995)*


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- Birds
  - waterfowl, other waterbirds, passerines, upland game birds, raptor (known since 1800s)

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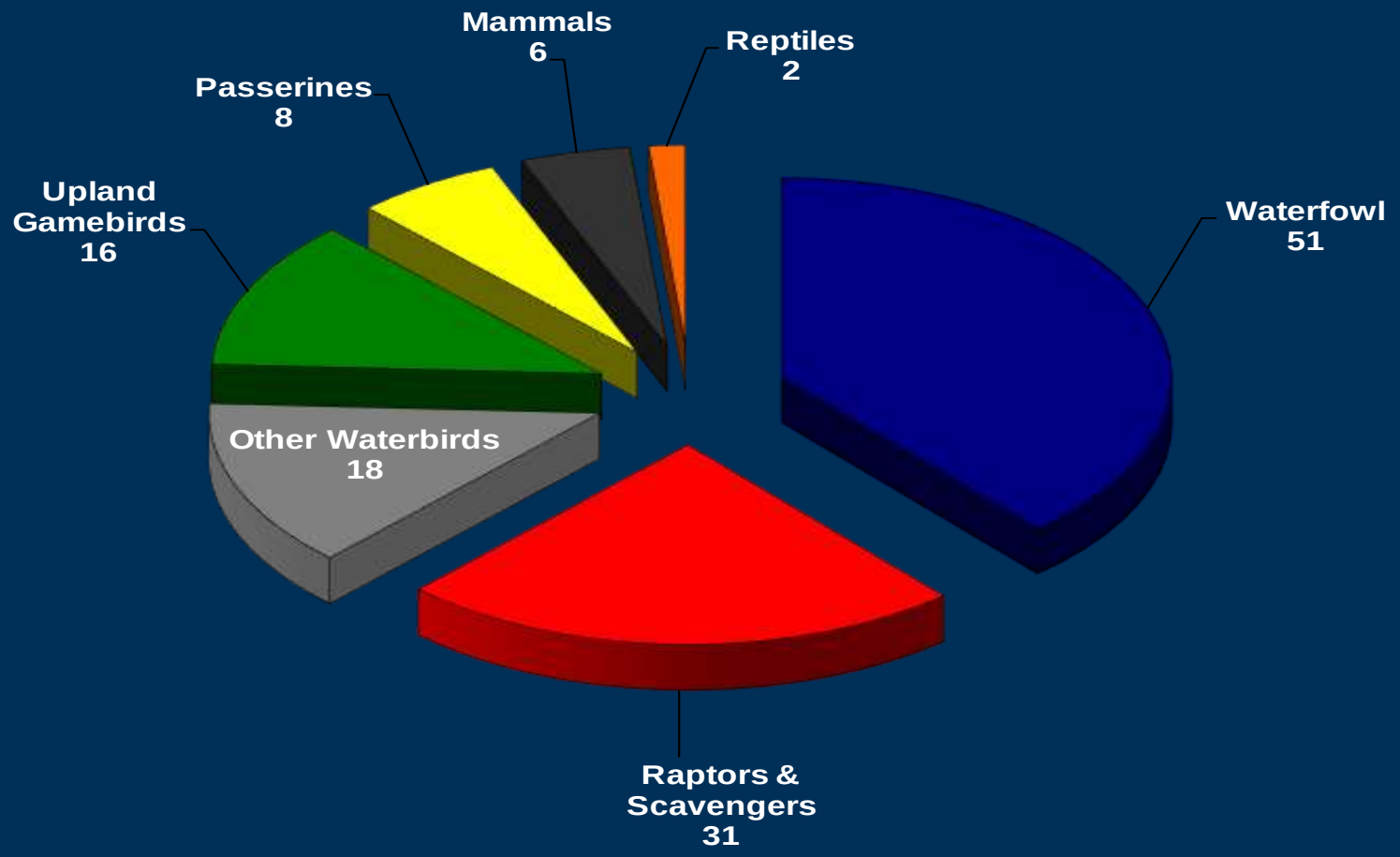
Species affected (as of 2008)



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Tranel and Kimmel 2008

The numbers – birds

- 23% of 522 dead loons ingested lead (New England)
- 1-23% game birds ingest lead pellets
- 1-60% game birds elevated blood lead level
- Lead: by far the leading cause of death of condors
- 100% of 108 vultures (VA) – chronic lead poisoning
  - *Kendall et al. 1996, Pokras et al. 2008 Behmke et al. 2015, USFWS 2019*

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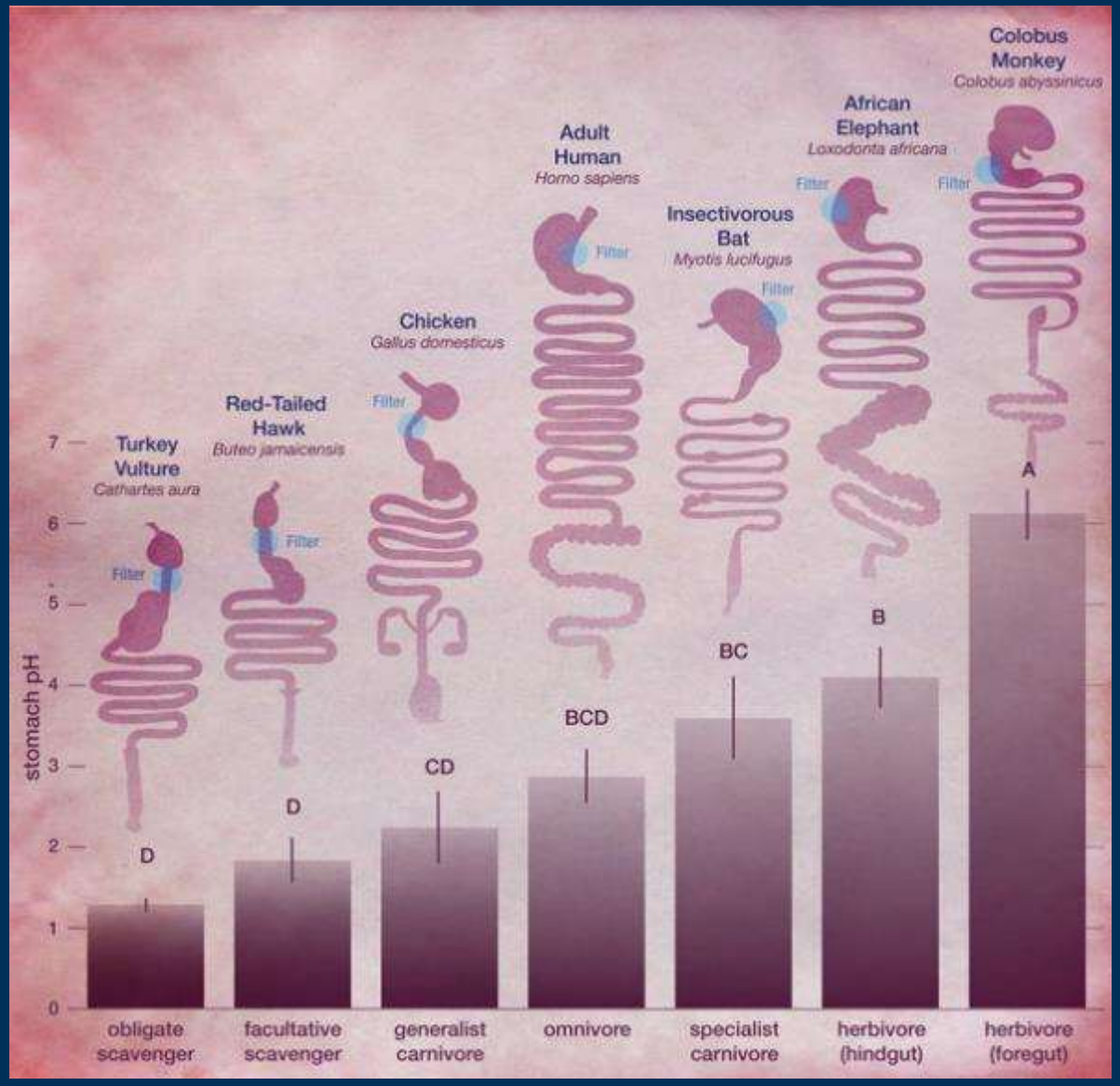

Stomach pH by trophic group
Beasley et al. 2015

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Avian predators and scavengers - global issue

- North America – condors, eagles, loons, etc.
- Australia - eagles
- Asia – vultures, eagles
- South America - condors
- Europe – eagles, vultures, etc.
- Africa - vultures

- *Evidence*
  - *seasonal, spatial, isotopic*

The Peregrine Fund

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From individuals to populations

- Treatment options available for individuals
  - Often effective, side effects
    - *Fallon et al. 2017*

- Populations also affected
  - Loons – 43% reduction in growth rate over 23 yrs in NH
  - Condors – Pb is main factor limiting recovery
  - Raptors in Europe – suppressing 10 species
  - Bald and golden eagles in North America
    - *Grade et al. 2017, Finkelstein et al. 2012, Green et al. 2022, Slabe et al. 2022*

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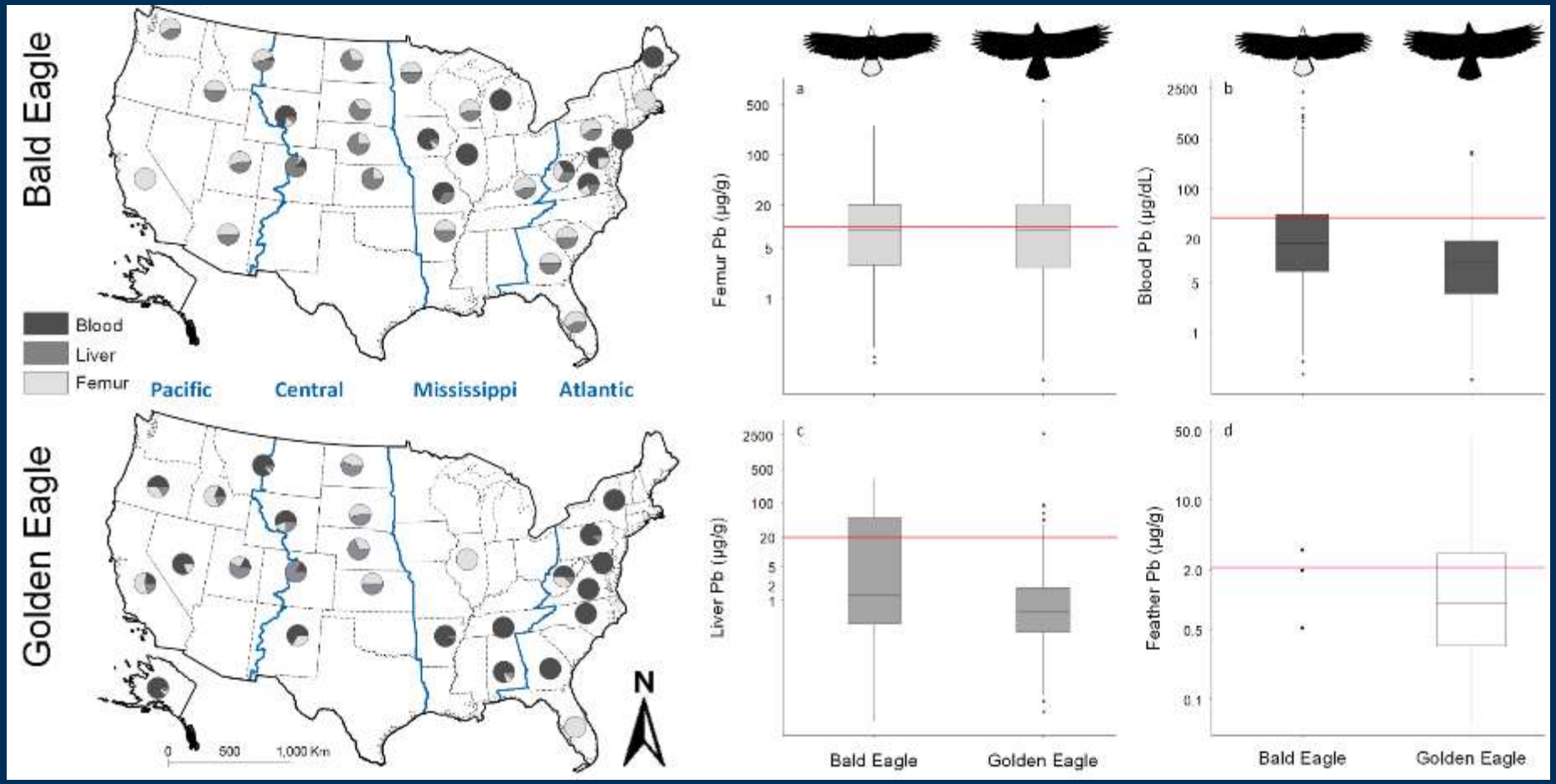
Lead poisoning of eagles

- ~50% eagles - evidence of chronic poisoning *(Slabe et al. 2022)*



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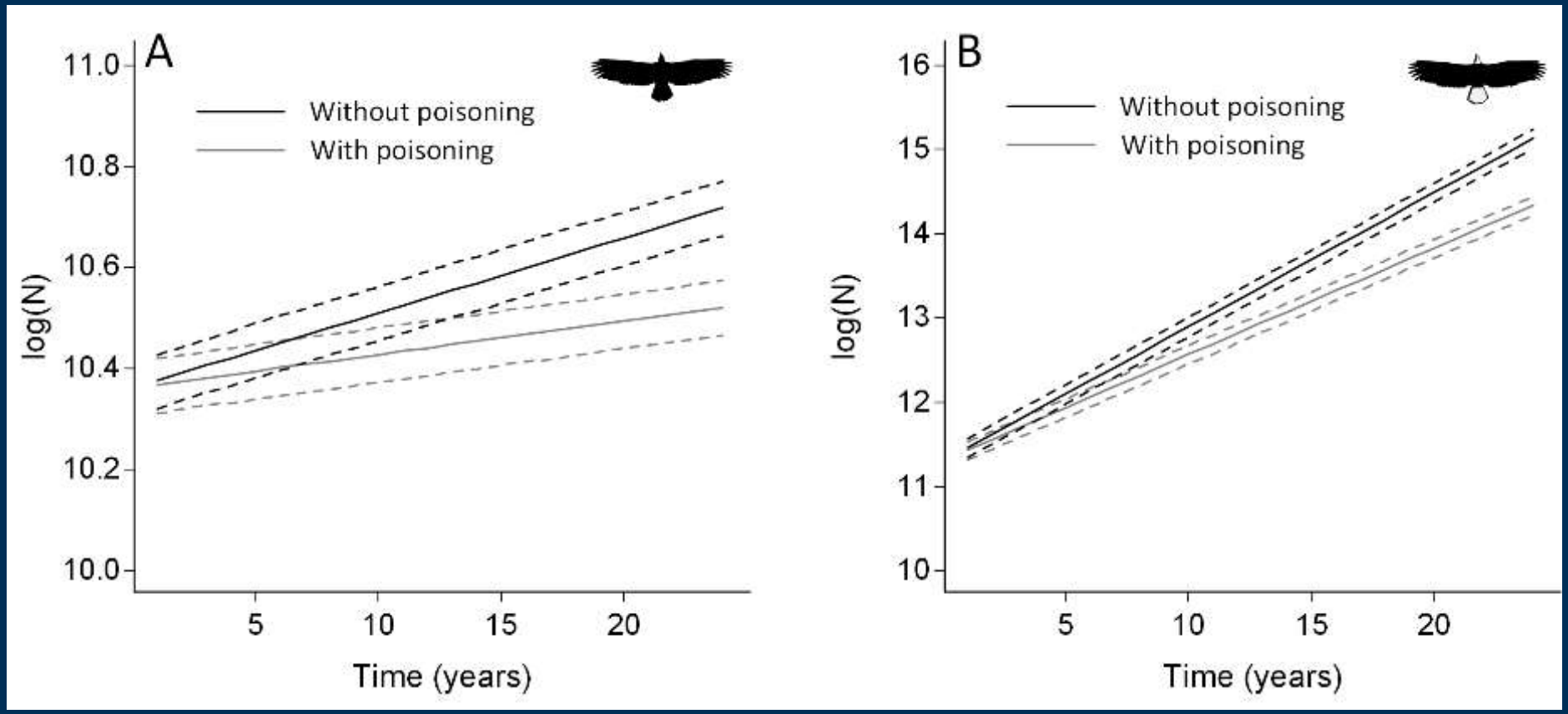
Lead poisoning of eagles

- Reduces populations both species in North America *(Slabe et al. 2022)*



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Lead poisoning of wildlife

- Across many trophic levels
- Has many potential sources
  - some far more important and pervasive than others
- Particularly relevant to avian predators & scavengers
- Solutions exist

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