The Industry Perspective, including Practical Considerations of Manufacturing Ammunition

Jonathan Gassett, Ph.D.
A little history...

WMI (Historically)
Funded by the firearms and ammunition manufacturers for almost 100 years. We functioned as the independent research arm for the industry to examine issues associated with wildlife restoration and conservation.

WMI (Today)
No longer funded by industry per se...

But through a Multi-state Grant, we currently function as the liaison between industry and state/federal agencies to help resolve issues associated with the federal excise tax (PR/DJ).
WMI's Role

Support the need for sound scientific information and analysis.

Encourage the development of alternate habitat and lead management approaches in field situations.

Advocate for hunter and industry involvement in policy decisions.

Engage in a deliberative and sound decision-making process.

Collaborate with federal and state agencies on lead management alternatives.
Lead is...

One of the most ancient metallic elements to be used by man.
Highly malleable, and can be easily worked into many forms.
Highly resistant to corrosion.
Extremely dense.
Produced globally in quantities exceeding 8 million tons annually and increasing.
Common and abundant in the earth’s crust, typically in ores of copper, silver, zinc, and galena.
Lead is...

Historically found in many common products such as:

- Paint
- Gasoline
- Ceramics
- Car batteries
- Wheel weights
- Pipe solder
- Ammunition

A serious biological toxin when ingested.
Other facts about lead...

Elemental lead is relatively stable, and bio-availability is low, especially when compared to the ionic lead salts found in paint and gasoline.

Elemental lead is capable of remaining stable in highly acidic environments - lead lining of containers for acid transport.

Lead is primarily used to make automobile batteries in the U.S.

(Incidentally, almost all lead used to make ammunition comes from recycled car batteries).
Lead is used in bullets for good reasons...

High density  
Low melting point (but not too low)  
Malleability  
Obturation (mushrooming)  
Ease of machining  
Chemical stability  
Metallic lead has low bio-availability  
Low cost

Currently, more than 95% of all bullets are lead-based
With exceedingly few exceptions, lead has had little impact on wildlife populations.
Environmental lead as a population-level impact

Evidence?
Some states that have proposed a lead ammo ban for upland game acknowledge there is no science to indicate population-level impacts, even for raptors, which have the best chance of ingesting lead ammo.

While there is currently a lot of attention on lead toxicosis in raptors, DDT was definitively proven to be the predominant cause of raptor population crashes until banned by the U.S. in 1972.

Since that time, many raptor populations, including Bald Eagles, have increased to their highest levels since we began monitoring.
Between the early 1980's and 2000, most states conducted annual bald eagle surveys. Since then, many states recognized that annual surveys were no longer necessary. That is why you will not see annual data after 2000.
California Condor Population Trends 2010-2016

Trend is slightly positive for the wild population, even though the period of 2008-2016 were a time of record-high ammunition sales and use.
• 279M doves estimated in the U.S. in 2016
• 800,000+ hunters
• 2.5M hunter days
• Numerous intensively hunted public fields
• 13.5M birds harvested annually
• No decrease in abundance in past 10 years
In cases where lead was determined to have population-level impacts, state and federal wildlife professionals have responded appropriately.
When necessary, agencies assess relative risks and take action

Species habitat, behavior, feeding

Dispersal of spent lead (geographic/tissues) lead concentration - density

Type of ammunition - fragmentation

Lead availability to prey and predator (game and entrails retrieval/burial)

Lead ingestion and intoxication

Impacts to populations
**Waterfowl**

Waterfowl have been intensively studied since the 1950’s.

Estimates of lead ingestion in waterfowl ranged from 3 to 7%.

Estimates of lead toxicosis in waterfowl were estimated at 2% mortality.

ESA Lawsuit against the USFWS - eagles (ingesting lead while preying upon sick and dying waterfowl).

*With Federal, State, NGO, and Industry involvement, the use of lead shot was phased out for waterfowl hunting in 1991.*
California Condors

Documented that elevated lead levels in blood cause lethal and sublethal effects.

One study indicated the lead isotopes found in blood matched lead ammunition isotopes.

(However, lead ammunition is manufactured from recycled automobile batteries)

Arizona implemented education and voluntary measures – including ammo exchanges for non-lead ammo, importance of carcass/gut pile removal, etc.

Lawsuit followed by legislation in CA.
California Ammo Ban

Lawsuit sponsored by the Humane Society of the U.S.

Wildlife Commission implemented a phase-in period

- Phase 1: Initially a ban implemented on state lands
- Phase 2: Shot for “large birds” and mammals (July 2016)
- Phase 3: All ammo, all hunting, statewide (July 2019)
  (Even though Condors do not occur statewide)

A study by Southwick and Associates indicates price increases and shortages are likely to result from the artificial demand created by California.
Mourning Dove Issues

Studies demonstrated lead toxicosis in both lab in field situations
• 1-4 #8 shot caused 24-52% mortality in 34 days
• 2-24 pellets caused 66% mortality in 21 days

Lead shot deposition
• Estimate - 200 to 330 million shells shot per year
• Missouri managed field - 1,425 hunters shot 40,000 rounds + 75,000 pellets per acre

Lead ingestion - grit/seeds
Lead embedded in tissues
Population level impacts?
Data Reviews

AFWA Non-toxic Ammunition Task Force

AFS/TWS Position Statement and Tech Review
  • 2008

USFWS
  • Waterfowl Hunting EIS

AFWA Ad Hoc Working Group – Doves
  • Established – September 2005
Additional Information Needed

Assessment of hunter/shooter opinions and attitudes

Field investigations re: pellet availability and ingestion
  • Managed v. unmanaged areas
  • State and flyway studies

Lethality tests

Develop, test, and approval of non-toxic alternatives

Develop a messaging/communication strategy
Chemistry, Physics, and Mechanics of Ammunition
What we have to work with...
<table>
<thead>
<tr>
<th>Metal or Alloy</th>
<th>Density (kg/m³)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>21400</td>
<td>$$$$$$</td>
</tr>
<tr>
<td>Plutonium</td>
<td>19816</td>
<td>Atomic weapons</td>
</tr>
<tr>
<td>Tungsten</td>
<td>19600</td>
<td>$$, brittle, too hard, AP</td>
</tr>
<tr>
<td>Gold</td>
<td>19320</td>
<td>$$$$$$ otherwise perfect</td>
</tr>
<tr>
<td>Uranium</td>
<td>18900</td>
<td>$$, radioactive, regulated</td>
</tr>
<tr>
<td>Mercury</td>
<td>13593</td>
<td>Liquid, poisonous</td>
</tr>
<tr>
<td>Lead</td>
<td>11340</td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td>10490</td>
<td>$$, werewolves lobby</td>
</tr>
<tr>
<td>Bismuth</td>
<td>9780</td>
<td>$$, availability, malleability</td>
</tr>
<tr>
<td>Copper</td>
<td>8930</td>
<td>$, obturation</td>
</tr>
<tr>
<td>Bronze (8-14% Sn)</td>
<td>8900</td>
<td>Armor piercing</td>
</tr>
<tr>
<td>Nickel</td>
<td>8800</td>
<td>$$, toxicity, allergen</td>
</tr>
<tr>
<td>Brass - rolled and drawn</td>
<td>8730</td>
<td>Armor piercing</td>
</tr>
<tr>
<td>Steel</td>
<td>7850</td>
<td>Armor piercing, hard</td>
</tr>
<tr>
<td>Cast iron</td>
<td>7800</td>
<td>Shatters, density</td>
</tr>
<tr>
<td>Wrought Iron</td>
<td>7750</td>
<td>Shatters, density</td>
</tr>
<tr>
<td>Tin</td>
<td>7280</td>
<td>Solder to bore, density</td>
</tr>
<tr>
<td>Zinc</td>
<td>7135</td>
<td>Density</td>
</tr>
<tr>
<td>Titanium</td>
<td>4500</td>
<td>Too hard, density</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2712</td>
<td>Density</td>
</tr>
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</table>
What do bullets need to do?

Bullet lethality is a function of energy transfer:

- Expansion
- Penetration
- Kinetic energy converted to shock and trauma

Currently the available non-lead bullets for big game are copper-alloy monolithic:

- Expand less
- Penetrate more
- Lower density
- Longer conformation
Bullet expansion

Lead bullets: “mushroom”
- Softness of metal
- Thickness of jacket
- Bonded or not
- Partition or shank limit
- Velocity

Copper alloy bullets: petals peel back
- Wall thickness
- Hollow cavity size
- Requires supersonic velocity for reliable expansion

Frontal diameter upon expansion is important
Terminal Performance

What the bullet does once it hits and passes through a target?

How animal is killed by a bullet...

- **Instantaneous**: Massive trauma causes changes in blood pressure that cause critical brain functions to stop immediately or other organs to fail.

- **Delayed**: Blood loss from wound trauma causes more gradual decrease in blood pressure and system shut down.

- **Catastrophic organ shut down**: Heart, spinal, brain.
# Bullet performance characteristics*

<table>
<thead>
<tr>
<th>Bullet Type</th>
<th>Bullet Length</th>
<th>Penetration</th>
<th>Expansion</th>
<th>Weight Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sierra Game King</td>
<td>1.20”</td>
<td>17.75”</td>
<td>0.8725”</td>
<td>83%</td>
</tr>
<tr>
<td>Fusion Rifle Ammo</td>
<td>1.20”</td>
<td>16.75”</td>
<td>0.9060”</td>
<td>91%</td>
</tr>
<tr>
<td>Nosler Partition</td>
<td>1.20”</td>
<td>24+”</td>
<td>0.6050”</td>
<td>67%</td>
</tr>
<tr>
<td>Trophy Bonded Tip</td>
<td>1.20”</td>
<td>23.25”</td>
<td>0.8725”</td>
<td>99%</td>
</tr>
<tr>
<td>Trophy Copper</td>
<td>1.50”</td>
<td>24+”</td>
<td>0.6270”</td>
<td>100%</td>
</tr>
</tbody>
</table>

*30-06 Springfield, 165 grain bullet shot into ballistic gel (bare)
Temporary Wound Cavity

- Bullet Path
- Temporary Wound Channel
- Cavitation Caused by Hydrostatic Shock
Graphic Depiction of Temporary Wound Channels

- Fusion®
- Trophy Bonded® Tip
- Trophy® Copper
- Varmint
- Solid
Other Considerations for Copper Ammunition

Rate of twist of current barrels may require lighter copper bullets
- Same length copper bullets weigh less due to density
- Longer bullets need more twist to stabilize
- For similar weight projectiles, hunters may need new rifles with longer barrels

Shot placement/ energy transfer
- Thicker, denser tissue will transfer energy better
- Shoulder shots may increase lethality but damage more meat
- Traditional shot placement may result in longer recovery time

Increased pass through, what is beyond the target?
The Economics of Manufacturing Ammunition
Metals Prices

Copper is usually 2 to 5x more expensive than lead.

Copper on September 22, 2017
$2.91/lb

Lead on September 22, 2017
$1.12/lb
## Available Metals in Descending Density

<table>
<thead>
<tr>
<th>Metal or Alloy</th>
<th>Density (kg/m³)</th>
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<tr>
<td>Platinum</td>
<td>21400</td>
<td>$1456/oz</td>
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<tr>
<td>Plutonium</td>
<td>19816</td>
<td>NA</td>
</tr>
<tr>
<td>Tungsten</td>
<td>19600</td>
<td>$22/lb</td>
</tr>
<tr>
<td>Gold</td>
<td>19320</td>
<td>$1241/oz</td>
</tr>
<tr>
<td>Uranium</td>
<td>18900</td>
<td>$37.75/oz</td>
</tr>
<tr>
<td>Mercury</td>
<td>13593</td>
<td>NA</td>
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<td>Lead</td>
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<td>$3.32/lb</td>
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*Note: The density values are approximate and can vary depending on specific conditions.*
Why does Copper Ammunition Cost More?

Lead and copper are both commodities, with prices affected globally. Ammo is a very minor player in either market.

Lead in ammo comes from recycled sources (car batteries). No lead mines still operational in U.S.

Copper comes primarily from mines. Environmental organizations are opposing mines in Minnesota, Alaska, and Arizona. Pebble Mine, anyone?

Copper is harder, requiring more/different tooling to fabricate bullets.

Copper has a higher melting point, requiring more energy inputs and creating a larger carbon footprint.

Ammo companies cannot share the input cost specifics because of anti-trust and competitive issues, but economics and physics are the primary players in the higher manufacturing costs.
Armor Piercing Ammunition

Armor piercing ammunition (18 U.S.C. 921(a)(17)(B)
A projectile or projectile core which may be used in a handgun and which is constructed entirely (excluding the presence of traces of other substances) from one or a combination of tungsten alloys, steel, iron, brass, bronze, beryllium, copper, or depleted uranium; or a full jacketed projectile larger than .22 caliber designed and intended for use in a handgun and whose jacket has a weight of more than 25 percent of the total weight of the projectile.
The term “armor piercing ammunition” does not include shotgun shot required by Federal or State environmental or game regulations for hunting purposes, a frangible projectile designed for target shooting, a projectile which the Attorney General finds is primarily intended to be used for sporting purposes, or any other projectile or projectile core which the Attorney General finds is intended to be used for industrial purposes, including a charge used in an oil and gall well perforating device.
New bullets being held up

Industry has submitted dozens of petitions for new bullets to the BATF, with the result of:

• No prospects of approval any time soon

• New alternative bullet developments being severely hampered due to fear of armor-piercing capabilities
Why is the lead issue important?
All PR revenue collected in 2016
$787,495,000
Funding for Wildlife Restoration Program (1937), Sport Fish Restoration Program (1950), and State Wildlife Grants (2001), since inception
Do hunters really shoot that much lead (~$300M per year)?

Some hunters are prolific, but most are not.

There was some “hoarding” of ammunition from 2008-2016...well, we don’t think we have seen it stop yet.

Most lead ammunition today is shot on ranges by recreational shooters. Ranges where lead recovery and recycling are feasible...but the PR excise tax is still paid and benefits wildlife conservation.
To Sustain and/or Grow Conservation

Focus on Increasing License Buyers and Participants
  • Remove or reduce barriers to entry
  • Recruitment, Retention, Reactivation (R3) efforts

Expand & Grow Public Support
  • Speak with one voice and show a unified front

Focus on Continued Industry Support
  • Work collaboratively with Industry and not as their opposition
Conflicting Messages to Industry

“We want to work with industry on a solution...”
“We want to ban 95% of your centerfire rifle products”

“The cost of alternative ammo is comparable to traditional ammo...”
“We want industry to offer discounts for our lead-free exchange programs because of the expense”

“We want non-toxic copper ammunition”
“Don’t permit any new copper mines”
Reducing lead ammunition is a far more reasonable goal

Bonded bullets reduce lead left in game animals.

Where needed, continue encouraging (and maybe funding) voluntary exchange programs as a viable alternative.

Hunter behavior - raising awareness of sensitive species (Where they leave gut piles may be important).

Work in partnership with industry (and help them politically/administratively to get more acceptable ammo to market).
Industry (and conservation) is between a rock and a hard place...

- Anti-hunters want to ban (Lead Ammo)
- ATF wants to ban (Alternative Ammo)
Other mitigation measures we can (and should) be encouraging right now...

- Disc and rotate state-owned managed fields
- Require lead abatement for fields leased to the state
- Ensure adequate additional sources of grit
- Require non-toxic shot on managed public fields
- Development and use of non-toxic ammunition
- Retrieval of game and carcasses from field
- Appropriate shooting range management
To summarize: If you are promoting alternative ammo...

Don’t minimize cost differential - it is real

Don’t minimize the differences in physical properties of the base materials - they are real

Don’t overstate accuracy or "Knockdown Power"

Don’t try to scare consumers with unsubstantiated human health concerns

Acknowledge and appreciate the role that lead ammo has had in conservation - 11% excise tax for more than 80 years
Is the juice worth the squeeze?

Conservation funding is inextricably woven into the lead ammunition issue, especially for state agencies. We are currently seeking 1.3B annually for conservation of at-risk species (Blue Ribbon Panel). Are we prepared to accelerate the loss of recreational sport hunters to a level that is unrecoverable? Are we willing to give up a portion of the more than $300M annually in revenue generated by ammunition sales? What will be our offset? What will be the true cost to conservation?
Questions?