S. HRG. 116–54

THEODORE ROOSEVELT GENIUS PRIZE: INNOVATIVE SOLUTIONS TO REDUCE HUMAN-PREDATOR CONFLICT

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

JULY 24, 2019

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ONE HUNDRED SIXTEENTH CONGRESS
FIRST SESSION

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C O N T E N T S

THEODORE ROOSEVELT GENIUS PRIZE: INNOVATIVE SOLUTIONS TO REDUCE HUMAN-PREDATOR CONFLICT

WEDNESDAY, JULY 24, 2019

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

The Committee met, pursuant to notice, at 10:03 a.m. in room 406, Dirksen Senate Office Building, Hon. John Barrasso (Chairman of the Committee) presiding.

Present: Senators Barrasso, Carper, Braun, Rounds, Ernst, Cardin, and Markey.

OPENING STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR FROM THE STATE OF WYOMING

Senator BARRASSO. Good morning. I call this hearing to order.

Earlier this year, Republicans and Democrats on this Committee joined together to enact a bill called the WILD Act; it is the Wildlife Innovation and Longevity Driver Act. These really smart people behind us come up with these acronyms, and it usually works; the WILD Act. The law supports innovative efforts to conserve wildlife, to manage invasive species, and to protect some of the world's rarest and most beloved animals.

The WILD Act established the Theodore Roosevelt Genius Prize to encourage technological innovation. These prizes annually award $100,000 to innovators who help solve our Nation's most difficult wildlife and invasive species challenges. The prizes were inspired by cutting edge conservation innovations that are already in use, such as the DNA analysis to identify the origin of illicit ivory supplies, thermal imaging to notify authorities of poachers, and a fish passage that automatically extracts invasive fish from systems.

So today, we will consider S. 2194, the Promoting Resourceful and Effective Deterrents Against Threats or Risks Involving Species. And you say, how do you come up with a name like that? Well, it is also called the PREDATORS Act; you take the first letter of each of those words.

The PREDATORS Act is a bill to establish a sixth Theodore Roosevelt Genius Prize, which I have introduced along with Senators Carper and Cramer and Booker. The bill would incentivize the development of non-lethal, innovative technologies that reduce conflict between human and wildlife predators. Although rare, human encounters with predators can lead to injury, and as we know, even death.

In Wyoming, the species most closely associated with this problem is the grizzly bear. Just last year, a hunting guide from Jackson Hole was tragically killed by grizzlies. The two grizzlies responsible for the attack were euthanized. And it is not just hunters that are at risk. In northwest Wyoming—Wapiti, Wyoming—the elementary school near Cody had to build an 8 foot high heavy gauge metal fence around its school yard to protect its students. You can see the image here; "Please close the gate for the safety of people and animals at Wapiti School."

Wyoming is not alone. It is not alone when it comes to grappling with human-predator conflicts. Fatalities occur each year from sharks. In 2018, there were 66 shark attacks, including 32 in the United States. A little over a week ago, a young girl boogie boarding in Florida suffered shark bites to her foot and ankle. Comparatively, she was lucky. In North Carolina, a girl lost a leg and two fingers while swimming this summer. An American woman was killed by shark in the Bahamas around the same time.

Bears and sharks are not the only predator species of concern. In Colorado, a runner's encounter with a mountain lion on a trail left him injured and the animal dead. Tragically, in Florida, a young child was killed at Disney World by an alligator.

Our distinguished panel is going to help us to examine how the establishment of a new Theodore Roosevelt Genius Prize can incentivize technological innovation to reduce future human-predator contact. Our witnesses include Brad Hovinga, who is the Jackson Regional Wildlife Supervisor at the Wyoming Game and Fish Department. I am going to formally introduce him shortly.

Forrest Galante, a biologist, wildlife tracker, and Host on Animal Planet, of Extinct or Alive, and we are thrilled to have you here joining us.

And Dr. Nick Whitney, who is a Senior Scientist for the Anderson Cabot Center for Ocean Life at the New England Aquarium, which is in Boston.

I look forward to hearing from our witnesses about their experiences with human-predator conflicts and how innovative technologies can help reduce them.

At this point, I would normally turn to Senator Carper. He has several different committee meetings today. He is going to be here shortly. And as I mentioned to Brad, we have a series of three votes starting at 11 o'clock. So we are going to have a lot of Senators attending. Some are going to be coming and going. You are going to have a lot of attention to this, because it is a topic of significant interest. As you see members coming and going, realize that they are going to different votes and different things. We are going to continue to keep the hearing going.

Before we hear from all of our three witnesses, I do want to welcome Brad Hovinga here, who has served as the Jackson Regional Wildlife Supervisor for the Wyoming Game and Fish Department during the last 4 years. He has worked with Wyoming Game and Fish since his graduation from Utah State University, where he was awarded a bachelor's degree in wildlife management. He has served over two decades as a district game warden in Big Piney, Wyoming, and in Lander, Wyoming, and in 2014, was named Offi-

cer of the Year for Wyoming from the Shikar Safari Club International.

In recent years, I have had the privilege of talking to him on different occasions about conservation issues affecting Wyoming. I think we have done it at the Elk Antler, the Boy Scout event that they have every year in Jackson Hole.

This Committee is certainly going to benefit from hearing about your vast experience in resolving predator-human conflicts in Wyoming.

Mr. Hovinga, we appreciate your being here. It is a privilege to welcome you as a witness before the Environment and Public Works Committee. Thank you for traveling to Washington, and we would like to now hear from you.

STATEMENT OF BRAD S. HOVINGA, JACKSON REGIONAL WILDLIFE SUPERVISOR, WYOMING GAME AND FISH DEPARTMENT

Mr. HOVINGA. Thank you, and good morning, Chairman Barrasso, members of the committee.

My name is Brad Hovinga; I am the Jackson Regional Wildlife Supervisor for the Wyoming Game and Fish Department. I appreciate the opportunity to be here today to provide my perspectives on technologies and practices of reducing human-wildlife conflicts. My testimony is based on 27+ years' experience as a game warden and a regional supervisor investigating these types of conflicts in Wyoming.

Today, I intend to highlight some of the important innovations and technologies currently employed by western wildlife management agencies to reduce human-wildlife conflicts, as well as present some ideas that have potential application for the future. Wyoming is home to a tremendous wildlife resource that is valued by a constituency that is passionate about their wildlife.

Human-wildlife interactions in Wyoming are typically the result of animals seeking unnatural foods in association with property or people, close encounters with humans, damage to property, or large carnivores that depredate livestock. The Wyoming Game and Fish Department makes a significant investment in wildlife-human attack response training and has its own response team to investigate and expertly deal with situations involving human injury or death caused by wildlife. Wyoming also puts forth a considerable educational effort, through our Bear Wise program, that seeks to minimize human-bear conflicts.

Wildlife agencies use a variety of innovative, non-lethal technologies to aid in reducing conflicts. These technologies include the use of chalk and pepper balls, weapon fired beanbags, a variety of pyrotechnics, and unmanned aerial vehicles, or UAVs. Wyoming recently trained personnel in the use of conducted electrical weapons, commonly known as tasers, for use as an aversion tool for wildlife. Colorado and Alaska have seen positive results with these devices with wildlife conflicts in those situations.

Many of the non-lethal technologies used today to reduce and prevent human-wildlife conflict have limitations that could be potentially be improved to increase their effectiveness. The technologies that I will discuss now either currently are in use and have the potential of being improved, or new technologies that I en-

vision having a fundamental impact on the future of reducing human-wildlife conflicts.

Bear spray is frequently a primary tool used in close quarters human-bear conflict situations and often does an excellent job in deterring animals in close contact situations, when used correctly. However, in extreme weather conditions, range and effectiveness of the spray can become limited and have an adverse effect on the individual deploying the bear spray.

Conducted electrical devices are quickly becoming a valuable tool for wildlife managers as an aversive conditioning technique, as well as a temporary immobilization tool on animals like urban deer. However, in order for effective use on large animals, such as grizzly bears and moose, the current technology is lacking options for long range deployment that would increase opportunities to use the technology and improve human safety.

Improvements in unmanned aerial vehicles, or drone technology, that allow for the deployment of aversive conditioning tools would greatly improve our ability to keep people safe and influence the behavior of habituated or aggressive wildlife. Developments in FLIR and thermal camera technology for the use with UAVs would significantly increase human safety when assessing dangerous situations.

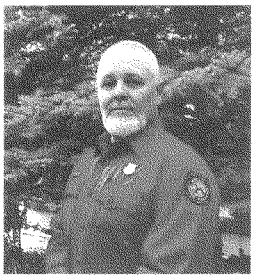
Last, long range acoustic sound devices, or sound cannons, are devices that directionally deliver sound over long distances. The potential for development of long range acoustic deterrents for wildlife management exists. Work to develop an appropriate aversive conditioning tool for addressing wildlife conflicts would be greatly beneficial.

The citizens of the United States have a deep and sincere appreciation for wildlife resources, and expect wildlife managers to understand and improve upon past and current technologies to reduce human-wildlife conflicts. Investigating ways to minimize the pitfalls and reduce the inadequacies of current technology and techniques is a great place for us to focus our work.

The wildlife populations continue to expand into human dominated landscapes in Wyoming and throughout the West. Human development continues to encroach on wildlife habitat. Development of new, innovative solutions that carry greater effectiveness at reducing conflicts between humans and wildlife is paramount to the co-existence of people and wildlife.

I thank you for the opportunity to share my perspectives and those of the Wyoming Game and Fish Department on reducing human-wildlife conflicts. I look forward to answering your questions.

[The prepared statement of Mr. Hovinga follows:]



Brad Hovinga
Jackson Regional Wildlife Supervisor
Wyoming Game and Fish Department

Mr. Hovinga graduated from Utah State University with a bachelor's degree in wildlife management. The Wyoming Game and Fish Department hired him almost immediately after receiving his bachelor's degree, and he has spent 23 years as a district game warden in Big Piney and Lander, Wyoming. Four years ago, Hovinga was promoted to the Jackson regional wildlife supervisor where he oversees the operations of the wildlife division in Jackson, Wyoming. He supervises both law enforcement and non-law enforcement employees. He is married with two daughters, ages 16 and 12.

WYOMING GAME AND FISH DEPARTMENT

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TESTIMONY OF BRAD S. HOVINGA
JACKSON REGIONAL WILDLIFE SUPERVISOR
WYOMING GAME AND FISH DEPARTMENT
JULY 24, 2019

BEFORE THE U.S. SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

Technologies for Reducing Human/Wildlife Conflicts

Good afternoon Chairman Barrasso, Ranking Member Carper and members of the Committee. I am Brad Hovinga, Jackson Regional Wildlife Supervisor for the Wyoming Game and Fish Department (WGFD). I appreciate the opportunity to be here today to provide my perspectives on technologies and practices for reducing human/wildlife conflicts. My testimony is based on 27+ years as a game warden and Regional Wildlife Supervisor dealing with human/wildlife conflicts in Wyoming. I have considerable field experience investigating human/wildlife conflicts involving large carnivores (grizzly bears, black bears, mountain lions and wolves) and large ungulates, particularly moose.

Wyoming is home to a tremendous wildlife resource that is valued by a constituency that is passionate about their wildlife. The state's wildlife habitats continue to provide remote and wide-open spaces for western iconic species like grizzly bears, wolves, moose and elk. The management of all wildlife species in Wyoming requires striking a delicate balance between the components of the state's economy that includes agriculture, tourism, hunting and mineral extraction. At the same time, we share management responsibility of these wildlife populations that know no boundaries with our surrounding states, as well as Yellowstone and Grand Teton National Parks. Consequently, we must all work together to manage, through communication and information sharing, these species and be the best stewards of the wildlife resource in the long run. This particularly holds true in the management of human/wildlife conflicts. State and federal agencies must communicate and collaborate in order for managers to ensure the most effective techniques and technologies are implemented to reduce conflicts between people and wildlife. In Wyoming, as populations of large carnivores such as grizzly bears continue to expand into human dominated landscapes, conflicts between humans and bears will likely increase.

Today I intend to highlight some important innovations and technologies currently employed by western wildlife management agencies to reduce human/wildlife conflicts, as well as present some ideas that have potential for the future. I am hopeful Committee Members will come to understand the value of commitment to research and collaboration with regard to new and

innovative technologies that aid in reducing human/wildlife conflicts. I offer my testimony from the perspective of a Wyoming wildlife manager that works closely with local game wardens and wildlife biologists, as well as other state and federal agencies, and a vast array of publics. While I tend to convey my experiences based on my work in the state of Wyoming, I will also offer thoughts based on my collaboration with and knowledge of other wildlife management agencies.

Background

In Wyoming, when discussing human wildlife conflicts, the discussion typically revolves around grizzly bears. Although Wyoming has a host of other large carnivores, conflicts between humans and black bears, mountain lions and wolves are significantly lower than with grizzly bears. Throughout my testimony I will tend focus on grizzly bears, however techniques and technologies for reducing human/grizzly bear conflicts generally apply to other large carnivores and ungulates.

Distribution and Abundance of Grizzly Bears

From 1990 through 2018, the area of occupied Greater Yellowstone Ecosystem (GYE) grizzly bear range has increased steadily at a rate of 4% per year from just over 23,000 km^2 to over 68,000 km^2. Grizzly bear occupied range now includes 97.5% of the Demographic Monitoring Area (DMA), and has expanded 20–30 km beyond the DMA boundary to the east and west and by nearly 60 km to the south. By 2018, nearly 30% of GYE grizzly bear range was outside the DMA boundary.

In 1990, just over 600 km^2 of private lands were encompassed within GYE grizzly bear occupied range, an area just half the size of Grand Teton National Park. By 2018, nearly 12,000 km^2 of private lands occurred within occupied range, an area larger than Yellowstone and Grand Teton National Parks combined. As grizzly bears advance into more human-dominated areas, they are also encountering an ever-larger human presence. The human population in the GYE has doubled since 1970 and is projected to double again by 2050 (Hansen and Phillips 2018). Visitation to Yellowstone National Park topped 4 million visitors each year since 2015. A consequence of this increased human population and range-wide grizzly bear expansion is the increased potential for human-bear conflicts, which has been shown to increase with increasing road density and human development (Schwartz et al. 2010).

Conflict Types and History

Human-bear interactions and conflicts in Wyoming are typically a result of bears seeking unnatural foods in association with people and property, close encounters with humans, property damage or when bears depredate livestock. The number and location of human-bear conflicts is influenced by unsecured unnatural attractants (e.g., human foods, garbage), natural food

distribution and abundance, bear density and distribution, and human and livestock use patterns on the landscape. The preferred resolution to minimize human-bear conflicts in Wyoming is through preventative measures or to secure the bear attractant. In addition, the WGFD manages grizzly bears in accordance with state and federal law, regulation, and policy. Capturing bears in areas where they may come into conflict with people and relocating them to remote locations is a common practice throughout the world. Relocating bears achieves several social and conservation functions: 1) reduces the possibility of property damage, livestock damage, or human interactions in areas where the potential for conflict is high; 2) reduces the potential for bears to become food conditioned or human habituated, which often results in destructive and dangerous behaviors; 3) allows bears the opportunity to forage on natural foods and remain wary of people; and 4) may prevent removing bears from the population, which may be beneficial in meeting population management objectives. The practice of relocation has served as an integral conservation tool to provide for recovery for GYE grizzly bears for multiple decades. Removal refers to lethal or live removal (e.g., placement with a zoo or other captive bear facility) from the population.

As a result of numerous and diligent education and conflict prevention efforts, the general pattern of conflicts is relatively steady to increasing within suitable grizzly bear habitat. However, as occupied grizzly bear range has expanded, conflicts continue to occur in areas further from the Primary Conservation Area and outside the DMA, often on private lands. Bears are increasingly coming into conflict with people in areas where grizzly bears have not been present in recent history. Although the joint efforts of the WGFD, U.S. Forest Service, non-governmental organizations, and particularly the public have resulted in reducing conflicts through education and attractant storage in many areas, the number of grizzly bear conflicts in Wyoming was high in 2018. Grizzly bears frequent lower elevations and developed areas regularly during the non-denning period. Grizzly bear-cattle depredation was the most frequent type of conflict documented in 2018. The annual variation in livestock depredation incidents is not easily explained. Although most human-grizzly bear conflicts are correlated with natural food abundance, the number of cattle and sheep killed annually do not follow the same pattern. As grizzly bears expand further into human-dominated landscapes outside the DMA, the potential for conflict between grizzly bears and humans increases, resulting in negative outcomes for both grizzly bears and people. The WGFD continues to explore and enable multiple options to reduce grizzly bear-livestock conflicts.

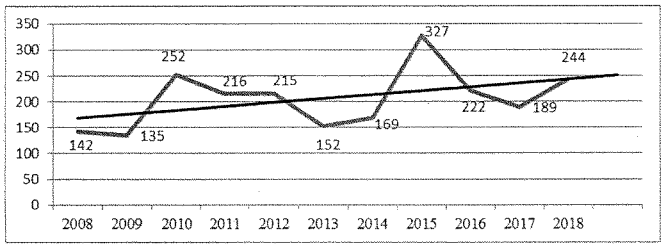


Fig. 1. Number of human-grizzly bear conflicts in Wyoming portion of the Greater Yellowstone Ecosystem, 2008-2018.

In recent years, the majority of conflicts in Wyoming occurred on public lands outside of the Primary Conservation Area. The increasing distribution of grizzly bears is reflected in the annual documentation of conflicts further from this area and continued expansion outside the DMA. As bears expand and occupy habitats commonly used by humans, there is a greater potential for conflicts to occur. Education and conflict-prevention efforts are used anywhere bears and people coexist, and management actions will be a function of human values and effects on the grizzly bear population in those areas.

Long-term trends in the number of conflicts is likely a result of grizzly bears increasing in numbers and distribution and expanding into areas used by humans, including livestock production, on public and private lands. As the GYE grizzly bear population continues to grow and expand into less suitable habitat, bears are more likely to encounter food sources such as garbage, pet food, livestock and livestock feed, and myriad other attractants, resulting in increased property damage and threats to human safety. Conflict prevention measures such as attractant storage, deterrence, and education are the highest priority for the WGFD. In general, there is an inverse relationship between social tolerance and biological suitability for bear occupancy in areas further from the Primary Conservation Area due to development, land use patterns, and various forms of recreation. Although prevention is the preferred option to reduce conflicts, each situation is managed on a case-by-case basis with education, securing of attractants, relocation or removal of individual grizzly bears, or a combination of methods are used for both short and long-term conflict resolution.

Throughout Wyoming and the GYE we have documented an increase in the number and distribution of conflicts as well as a shift in the primary types of conflicts (see associated figures and tables below). Through collaborative efforts instances related to securing of attractants, conflicts such as property damage have decreased, whereas as grizzly bears have expanded outside of the recovery zone and other suitable habitats within the DMA we have documented increases in livestock depredation and other site-specific conflicts. In more recent years we have

documented multiple instances of human injuries and some examples of human fatalities. When looking at where conflicts occur spatially, we note that approximately 1/3 of all verified grizzly bear conflicts in Wyoming are occurring outside of the DMA in less suitable habitats where we do not manage for grizzly bears (see figure 2).

Conflict Type (5 yr. average)	**2009-2013**	**2014-2018**
Property Damage	25	14
Livestock Conflict	97	143
Garbage	23	29
Self Defense/Other GB Deaths	6	6
Human Injury/Death	3	4

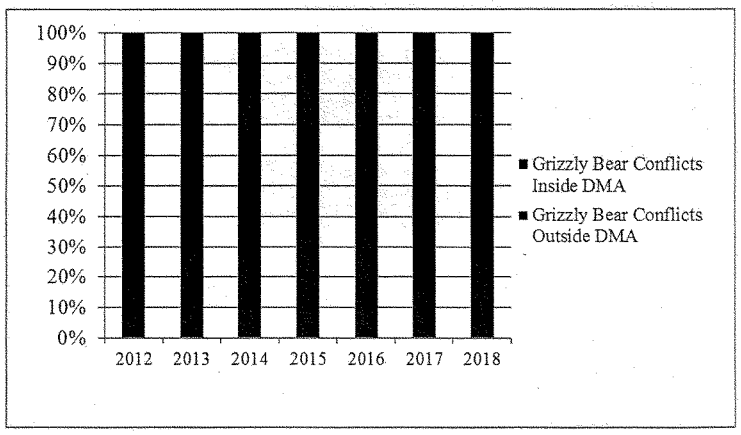


Figure 2. Comparison of verified grizzly bear conflicts in Wyoming inside and outside suitable habitats within the Demographic Monitoring Area.

Human/wildlife Conflict Technology and Practices

WHART/PAT team

WGFD has trained professionals throughout the state that function as a Predator Attack Team (PAT). These individuals annually conduct and attend training to efficiently and expertly deal with situations involving human injury or death caused by wildlife, in this case grizzly bears. The WGFD revised their PAT guidelines in 2016 and continues to evaluate their guidelines and infrastructure to respond to human injuries and fatalities in a professional and efficacious manner. In addition to internal training, Department personnel annually attend Wildlife Human Attack Response Team (WHART) training exercises throughout North America to learn from other agencies and provide insight to how human injuries and fatalities are dealt with by the WGFD. The Large Carnivore Conflict Coordinator serves as the WGFD PAT lead and is the representative to other agencies, This position is annually is invited to provide training and symposia on our program.

Bear Wise Program (Education and Outreach)

The Bear Wise Program is a proactive initiative that seeks to minimize human-bear (black and grizzly) conflicts, minimize management-related bear mortalities associated with preventable conflicts, and to safeguard human communities in northwest Wyoming. The overall objective of Bear Wise is to promote individual and community ownership of ever-increasing human-bear conflict issues, moving toward creating a social conscience regarding responsible attractant management and behavior in bear habitat. This project seeks to raise awareness and proactively influence local waste management infrastructures with the specific intent of preventing conflicts from recurring. Strategies used to meet the campaign's objectives are: 1) minimize accessibility of unnatural attractants to bears in developed areas; 2) employ a public outreach and education campaign to reduce knowledge gaps about bears and the causes of conflicts; and 3) employ a bear resistant waste management system and promote bear-resistant waste management infrastructure.

In 2004, a subcommittee of the Interagency Grizzly Bear Study Team (IGBST) conducted an analysis of causes and spatial distribution of grizzly bear mortalities and conflicts in the Greater Yellowstone Area (GYA) for the period of 1994–2003. The analysis identified that the majority of known, human-caused grizzly bear mortalities occurred due to agency management actions in response to conflicts (34%), self-defense killings, primarily by big game hunters (20%), and vandal killings (11%). The report made 33 recommendations to reduce human-grizzly bear conflicts and mortalities with focus on 3 actions that could be positively influenced by agency resources and personnel: 1) reduce conflicts at developed sites; 2) reduce self-defense killings; and 3) reduce vandal killings.

To address action number 1, the subcommittee recommended that a demonstration area be established to focus proactive, innovative, and enhanced management strategies where developed site conflicts and agency management actions resulting in relocation or removal of grizzly bears had historically been high. Spatial examination of conflicts identified the Wapiti area in northwest Wyoming as having one of the highest concentrations of black bear and grizzly bear conflicts in the GYA. The North Fork of the Shoshone River west of Cody was then chosen as the first area composed primarily of private land to have a multi-agency/public approach to reducing conflicts at developed sites.

In 2005, the WGFD began implementation of the Bear Wise Community Program. Although the program's efforts were focused primarily in the Wapiti area, the Department initiated a smaller scale project in Teton County to address the increasing number of black and grizzly bear conflicts in the Jackson, Wyoming area. For the last 12 years, the Bear Wise Community Programs in Northwest Wyoming have deployed a multi-faceted education and outreach campaign in an effort to minimize human-bear conflicts and promote proper attractant management. Although a wide array of challenges remains and vary between communities, many accomplishments have been made and progress is expected to continue as Bear Wise efforts gain momentum. In an effort to broaden the scope of the program, this work was rebranded as the Bear Wise Wyoming Program.

Human Wildlife Conflict Techniques

The Department employs a wide array of techniques to reduce, prevent, and resolve conflicts. As mentioned earlier, the outreach and education serves as the proactive foundation to reduce conflict potential before a situation occurs. A great deal of effort by our personnel is devoted to working with the public to secure attractants; attractants range from garbage and livestock feed, to apple trees and bee apiaries, requiring a multi-faceted approach to how attractants are secured. We work closely with local communities to provide bear proof infrastructure for garbage as well as a great deal of electric fencing around larger attractants (i.e., chicken coops, cornfields, apiaries, fruit trees). These proactive measures have reduced instances of property damage and other conflicts, but as bears expand their distribution the footprint of action is harder to maintain.

WGFD personnel also use varying methods of non-lethal aversive conditioning with bears in an attempt to deter behavior such as habituation to residential or roadside areas. Aversive conditioning can come in the form of air horns and horn honking to that of chalk/pepper balls, bean bags, cracker shells and other similar devices. Other agencies have initiated program using conducted electrical weapons (CEW, Taser™) as an aversive condition tool with positive results in Colorado and Alaska. WGFD personnel have received training and are in the process of adding this as another conflict prevention tool. Other technological advances in the form of drones and communicable cameras (via text/email) are facilitating more expeditious reconnaissance of potential conflict situations and aiding in human safety situations for the general public and our personnel.

The WGFD, through trained personnel in the Large Carnivore Section also employ the use of standard management strategies aimed at reducing/resolving conflicts through capture and monitoring efforts. Throughout occupied grizzly bear range, the WGFD staffs personnel devoted to dealing with human/grizzly bear conflicts and using aforementioned techniques to deal with any/all forms of conflict. Despite all proactive efforts, there are situations that require management attention through attempted capture and handling of grizzly bears. Dependent on multiple factors (and after consultation with the US Fish and Wildlife Service) decisions are made as to whether the animal is released, relocated, or removed from the population through placement into a live facility or euthanasia. The WGFD is constantly evaluating all of the combined techniques as to their efficacy toward reducing conflicts and conflict potential.

Future Technological and Conservation Needs

Many of the technologies used today to reduce or prevent human/wildlife conflicts have limitations or inadequacies that have the potential to be addressed to improve their effectiveness. Improving these technologies and minimizing their pitfalls helps to ensure the safety of both humans and wildlife. The technologies that I speak of now are either currently in use and in my view, have the potential to be improved, or technologies that I envision having a fundamental impact on the future of reducing human/wildlife conflicts.

Bear Spray – Improving effectiveness

Bear spray is often the "go to" tool in close quarters or immediate pending human-bear conflict situations and often does an excellent job deterring animals in close contact scenarios when used correctly. However, in extreme weather conditions (wind/heavy rain) the range and effectiveness can become limited and have an adverse effect on the individual deploying the bear spray. Strong crosswinds can cause spray particles drift at much shorter distances, causing an ineffective application of the pepper spray by missing the intended target or reducing the amount of spray reaching the bear. Additionally, when the user deploys bear spray into a strong headwind and the pepper spray blows back into the user, the self-contamination effect of the spray particles certainly has an adverse effect on the user. Pepper gels are becoming more popular among law enforcement and personal protection customers for use on humans and have proven more effective against the adversities of wind and self-contamination. Advances in the technology for the use of pepper gels for use on wildlife would certainly be advantageous to reduce human/wildlife conflicts.

Conducted Electrical Devise – Taser

As mentioned earlier, conducted electrical devises are quickly becoming a valuable for tool wildlife managers as an aversive conditioning technique, as well as a temporary immobilization

tool. However, in order for effective use on larger animals, such as grizzly bears and moose, current technology is lacking options for long-range deployment. Technology allowing deployment of conducted electrical devises at ranges of 30 feet or greater would significantly increase opportunities to use conducted electrical devices to address large carnivore and ungulate conflicts.

Unmanned Aerial Vehicles (Drones)

I have previously mentioned the advantages of UAVs, or drones, in human safety situations and the benefits of that technology. Improvements in drone technology that allows for the deployment of aversive conditioning tools would greatly improve our ability to keep people safe and change behavior in habituated and aggressive wildlife. Having the ability to deploy bear spray and conducted electrical devises from UAVs would be significantly improve success in reducing human/wildlife conflicts by allowing greater opportunity to utilize these tools at much greater distances.

Acoustic Sound Deterrents

Long-range acoustic sound devices and sound cannons are devices that deliver very loud sounds over long distances. Law enforcement has utilized acoustic sound technology for crowd-control purposes since the early 1990s and our military has exercised various forms of acoustic sound tools for years. The potential for development of long-range acoustic deterrents for wildlife management exists and work to develop an appropriate aversive conditioning tool for addressing wildlife conflicts would be beneficial.

Electric Fencing

Earlier in my testimony, I mentioned valuable uses for portable electrical fencing in deterring large carnivores in order to protect agricultural crops. Portable electric fencing is also a valuable tool for deterring bears and preventing conflicts in back country situations, such as protecting livestock feed and cook tents in back country camps. Developments in new technology allowing for improvements to electric fencing options that include increasing portability, lightening the weight of equipment and batteries and improving battery strength and longevity are innovations that could increase the potential of portable electric fencing as a back country human safety tool.

Evaluation of Management

As managers, we constantly are assessing our strategies and action to ensure we continue to remain efficient and effective. In regards to managing grizzly bear conflicts this is accomplished through analysis of decades of intensive data collection and monitoring of the population and of our management strategies. As grizzly bear populations continue to expand beyond suitable

habitats we must be diligent in evaluation of strategies and adaptable in how we deal with conflicts from a management standpoint as to where we promote grizzly bear populations and our interactions with the people who live, work, and recreate in grizzly bear country. We are currently analyzing the efficacy of grizzly bear relocations as the population increases and are working to continually provide context to the public in regards to how data are portrayed, used, and misused. It is vital to portray how management action such as relocation and lethal removal are used as management strategies to reduce conflict between humans and grizzly bears that benefit both bears and people.

Human Dimensions

Social media and instantaneous information sharing has come to the forefront in highlighting our need to understand the human dimensions of human-wildlife conflicts. Interest and conflict are inherent with wildlife and humans cohabitating on the same landscape. A better understanding of how to successfully share information and communicate with a diverse public will increase our success in managing conflicts between wildlife and humans.

Conclusion and Summary

The citizens of the United States have a genuine appreciation for wildlife resources and expect wildlife managers strive to better understand and improve upon past and current technology in an effort to reduce human/wildlife conflicts. Investigating ways to minimize the pitfalls and reduce the inadequacies of current technology and techniques is a great place to focus our work. Wildlife populations continue to expand into human dominated landscapes in Wyoming and throughout the West, and human development is constantly encroaching on wildlife habitat. The opportunity for new and innovated solutions to arise that carry much greater effectiveness at reducing conflicts between humans and wildlife is paramount to the future of the coexistence between people and wildlife. These opportunities are most likely to develop through partnerships between private industries and government organizations with a reasonable and practical investment of financial resources in the initial stages of development.

Although much of what I have talked about today revolves around conflict between humans and grizzly bears, it is important to realize that developments on that front are likely to have significant application and provide solutions for conflicts between humans and other wildlife species. Technologies that are effective for grizzly bears would most certainly be an effective tool in dealing with conflicts involving moose, elk and other large carnivores.

I sincerely thank you for the opportunity to provide this testimony and share the perspectives of the Wyoming Game and Fish Department on reducing human/wildlife conflicts.

Senate Committee on Environment and Public Works
Hearing entitled, *"A Theodore Roosevelt Genius Prize: Innovative Solutions to Reduce Human Predator Conflict"*
July 24, 2019
Questions for the Record for Mr. Hovinga

Ranking Member Carper:

1. From acoustic deterrents to motion-activated alarms, there are many innovative, nonlethal technologies available that can help humans avoid unwanted interactions with predators. In your experience, how widespread is the use of these types of nonlethal technologies? What are the barriers currently preventing wildlife managers and the public from using them?

Currently, the Wyoming Game & Fish Department (WGFD) and most state wildlife management agencies employ the use of any/all non-lethal technologies available to deter unwanted interactions between wildlife and humans. The WGFD uses non-lethal technologies on a daily basis throughout the state to deter such conflicts. The only obstacle to use of these non-lethal technologies is public concern from individuals that do not want animals disturbed; however, that is not an actual barrier. Many of the non-lethal techniques require training and expertise and are not something that can or should be readily available to the public in their current form. Technological advancement through research could improve the safety and effectiveness of these technologies for use by the public.

2. Predators do not know boundaries as we do. They move freely from state to state, travel through public and private lands, and swim freely through state and federal waters. It only makes sense, then, that the diverse array of landowners and stakeholders that interact with predators have a hand in shaping conflict avoidance strategies. Would you please elaborate on the role that public participation can play in minimizing human-predator conflicts? Is there anything Congress can do to improve opportunities for public participation in helping different jurisdictions manage these species?

The WGFD works extremely close with all members of the public that work, live, and recreate in areas where large carnivores (grizzly bears, black bears, wolves and mountain lions) and other wildlife exist. Gaining community support and cooperation in areas where humans and large carnivores cohabitate is crucial to maintain public tolerance and support for wildlife, as well as sustaining carnivore populations on the landscape. Congressional support for the state management of wildlife and the programs that provide for interaction with the public regarding the management of large carnivores, such as Wyoming's Bear Wise Program, are critical to maintaining support for large carnivores on the landscape and wildlife population management objectives.

The WGFD Bear Wise Program is a proactive initiative that seeks to minimize human-bear (black and grizzly) conflicts, minimize management-related bear mortalities associated with preventable conflicts, and to safeguard human communities in northwest Wyoming. The overall objective of Bear Wise is to promote individual and community ownership of ever-increasing human-bear

conflict issues, moving toward creating a social conscience regarding responsible attractant management and behavior in bear habitat. This project seeks to raise awareness and proactively influence local waste management infrastructures with the specific intent of preventing conflicts from recurring. Strategies used to meet the campaign's objectives are: 1) minimize accessibility of unnatural attractants to bears in developed areas; 2) employ a public outreach and education campaign to reduce knowledge gaps about bears and the causes of conflicts; and 3) employ a bear resistant waste management system and promote bear-resistant waste management infrastructure.

3. You did not mention range riders or livestock protection dogs as potential conflict-prevention measures for grizzlies. Do you also see those measures as potentially effective tools in preventing human-grizzly conflicts?

Most, if not all, livestock producers in Wyoming that have livestock co-occurring with large carnivores employ the use of range riders and many use livestock protection dogs depending on the location. Some areas are difficult to use livestock protection dogs due to presence of wolves and grizzly bears (in addition to all other predatory species). We work closely with livestock producers to identify any potential techniques to reduce conflicts. Range riders provide a great service in locating fresh killed livestock carcasses that allow for proper management actions by trained WGFD professionals.

4. In the hearing we discussed the importance of inventing and improving conflict prevention technology. However, for agencies like yours, is conflict prevention also a matter of resources? If the Wyoming Game and Fish Department had more resources available, whether through state or federal funding or public donations, would it be able to expand its Bear Wise and other human-bear conflict prevention programs?

Human/wildlife conflict prevention in Wyoming is absolutely a matter of resource allocation. The WGFD undertakes a monumental task in actively identifying efficiencies and working creatively to stretch the funds to cover all aspects of conflict resolution and our Bear Wise program. However, additional funding and support for these types of programs always provides a significant boost in our ability to assist the public through our work to reduce human/wildlife conflicts and expand programs to reach more of our publics. As large carnivores expand their footprint in Wyoming, our educational and conflict resolution footprint also expands.

Senator Whitehouse:

5. The Wyoming Game and Fish Department's State Wildlife Action Plan describes climate change as one of five "Leading Wildlife Conservation Challenges." How is climate change affecting predators in Wyoming?

    a. Does climate change have a role in contributing to potential human-predator conflicts?

The effects of climate change on predators in Wyoming is very complex and involves multiple factors influence conflict potential between humans and predators. Long-term changes in habitats have the potential to influence all wildlife including predators/large carnivores. The WGFD continually evaluates environmental conditions, conflict management and conflict ecology between humans and carnivores in order to adaptively manage conflict potential on the ground. Large carnivores in Wyoming are highly adaptable. The increases in conflict between grizzly bears and humans that is documented in Wyoming is a direct result of increased distribution and abundance of grizzly bears and co-occurrence of grizzly bears and humans in less suitable habitats for long-term perpetuity of grizzly bears.

6. When was Wyoming's Predator Damage Management program last updated?

    a. How many predators are killed (or "lethally controlled") each year under that program?
    b. How many non-target animals are killed each year?

Although the WGFD participates on the Wyoming Animal Damage Management Board (ADMB), the ADMB does not operate under the authority of the WGFD. The ADMB is continually developing new educational plans, brochures, programs or displays to meet current program needs and to promote their efforts. The mission of the ADMB is to coordinate and implement an integrated animal damage management program, based on the best available science, for the benefit of human and natural resources throughout Wyoming. The ADMB was established in 1999 for the purposes of mitigating damage caused to livestock, wildlife and crops by predatory animals, predacious birds and depredating animals or for the protection of human health and safety. The ADMB is specifically designed to address conflicts involving "predatory animals", which by state statutory definition are animals **not** under the management authority of the WGFD. Wyoming state statues define "predatory animals" as coyote, red fox, skunk, porcupine, jackrabbit, raccoon and stray cat. Detailed information about the ADMB can be found at http://www.wyadmb.com/index.htm. The WGFD does not have information regarding the number of "predatory animals" taken under actions by the ADMB, county predator management boards or USDA-APHIS-Wildlife Services, or information regarding non-target animals killed.

7. Are M-44 cyanide bombs or other poisons used by state or federal officials to lethally control predators in Wyoming?

    a. How many non-target animals, including pet dogs, have been harmed by these controls?
    b. Is Wyoming exploring or currently using non lethal strategies and tools to manage predators and other wildlife?

The WGFD does not use M-44 cyanide bombs or other poisons to lethally remove any wildlife in Wyoming. USDA-APHIS-Wildlife Services occasionally uses poisons to manage coyote and red fox (predators not managed by the WGFD) in livestock conflict situations. I do not have knowledge of USDA-APHIS-Wildlife Services use of poisons in Wyoming, or their effects on non-target animals.

The WGFD does use a variety of non-lethal technologies and strategies extensively to manage large carnivores and other wildlife conflicts in Wyoming. WGFD use varying methods of non-lethal aversive conditioning with bears in an attempt to deter behavior such as habituation to residential or roadside areas. Aversive conditioning can come in the form of air horns/horn honking, chalk/pepper balls fired from a gun, weapon fired beanbags, cracker shells and other similar devices. In other situations, various lighting, noisemaking and visual devices deter the presence of wildlife in areas of conflict.

Senator BARRASSO. Thank you so very much for your testimony.

Now I would like to turn to Mr. Forrest Galante, who is the host on Animal Planet of Extinct or Alive.

Welcome to the Committee.

STATEMENT OF FORREST GALANTE,
WILDLIFE BIOLOGIST AND HOST, ANIMAL PLANET

Mr. GALANTE. Thank you very much, Chairman Barrasso, Ranking Member Carper, and members of the Committee. Thank you for the opportunity to be here today.

I am a wildlife biologist and animal tracker. For as long as I remember, I have looked for wildlife to experience seeing them in their natural habitat. I grew up on a farm in Zimbabwe. The land was home to flowers, fruits, livestock, and wild animals.

As a boy, I enjoyed catching snakes, fishing in the dam, and exploring the remote African bush with my mother, one of Africa's first female safari guides and bush pilots. I was enthralled by all wildlife. I learned their behavior, how they survive and thrive, and what threatens them in their existence. From a young age, I knew I would pursue a career in wildlife.

I am honored to be here today to offer my perspective on human-predator conflict, and how traditional and innovative techniques can be used to reduce conflicts and benefit humans, wildlife, communities, and habitats. I applaud the Committee's leadership role in establishing the five Theodore Roosevelt Genius Prizes. Now signed into law, this legislation encourages innovation to address growing challenges in protecting wildlife.

I also applaud the Committee for introducing new legislation, the PREDATORS Act, to add a new award to incentivize solutions to reduce human-predator conflict. Growing up in Africa, the conflict between predator and human is a daily struggle that I witnessed first hand, from leopards stealing livestock to people actually being preyed upon by species like crocodiles, lions, and more.

Unfortunately, in the long term, the predator almost always loses, as eradication has typically been the method of resolution. However, innovative methods of predator deterrents have begun to arise. These deterrents could easily become the new standard. They will not only resolve the issue, but support local economies by keeping the valuable apex predators in the system, which not only helps the biome, but supports ecotourism.

Many of these methods are still in development and have typically been crudely implemented by scientists like myself attempting to resolve a problem with little resources. I want to emphasize that an understanding of animal behavior and the ecology of a species is essential to developing successful deterrents.

The following is a list of non-lethal deterrents. Animatronic deterrents. In Malawi, there was an infamous hyena that used to raid village flocks. An engineer friend of mine came up with a fascinating animatronic decoy. Because hyenas fear large animals and men, he built a large motion activated animatronic scarecrow to place at the entry points of the village. With solar panels to power them, they will scare away hyenas that come near. This is a permanent fix that requires a bit of engineering to be sustainably successful.

Alarm systems. There are really two types, foreign and organic. A foreign alarm is a sound or light not recognized and startling to an animal; an organic one is using something the animal is naturally deterred by, such as a competitor's growl. Setting these up by motion activation has proven successful for foxes, coyotes, leopards, and more.

Olfactory deterrents. Like organic alarm systems, an organic smell can oftentimes be enough to deter a predator. For instance, if you have a persistent problem with a coyote, spraying wolf urine around the perimeter can deter the coyotes from entering the area.

Commensalistic deterrents. In many cases, using an animal to deter another animal has no negative effects. This is simply the sheep dog approach. Living in Africa, we would see that trained packs of Rhodesian Ridgeback dogs were a fantastic permanent solution to deterring lions. They stay close to home, create an alarm system, and will easily run off a lion that is trying to sneak in for a free meal.

Barrier methods. In many places around the world, fresh water is the reason for predator-prey interactions. Using barriers to create safe swimming and washing areas in river systems can eliminate attacks by crocodiles, hippos, and other animals.

The list goes on, but the key element here is fully understanding the predator which we are trying to deter. The point is true for predators in any habitat.

There are several new pieces of technology that, once properly understood and implemented, will be the new standard. Before wrapping up, I would like to share a few quick examples.

The HECS technology is a passive technology that blocks the body's naturally occurring electric energy. Basically, by wearing a wetsuit that has the technology of a Faraday cage—the same thing that is in the door of your microwave oven at home—it blocks the body's naturally occurring energy signal. To a shark, you are now perceived as an inanimate object.

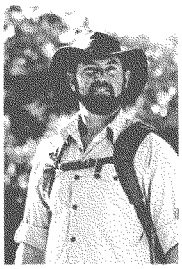
The shark shield is a lightweight, wearable electronic device. The patented technology creates a powerful three-dimensional electrical field which causes unbearable spasms in the sharks' sensitive EMR receptors, turning sharks away as soon as they come into contact with the electrical field.

The clever buoy is an ocean monitoring platform that specializes in detecting large marine life using sonar and identification software systems to relay critical information to authorities responsible for beach safety.

Once technology like the clever buoy system is perfected, implemented, and combined with something like the shark shield, you have a virtual net that can make a beach safe for any swimmers, which is just amazing, in my opinion.

Thank you again for inviting me to be a part of today's hearing. I look forward to answering any questions that you may have.

[The prepared statement of Mr. Galante follows:]



Forrest Galante
Wildlife Biologist and Host
Animal Planet

Forrest Galante is a wildlife biologist and host of Animal Planet's EXTINCT OR ALIVE committed to focusing on animals on the brink of extinction and dedicated to searching across the globe for animals he believes have wrongfully been written off as extinct. Galante aims to inspire and educate people about animals through his on-camera wildlife biology fieldwork; during his tenure with Animal Planet he has successfully captured evidence of the existence of two animals once believed to be extinct. In 2018, Galante found trail footage of a Zanzibar leopard deep within the jungles of Zanzibar. Then in 2019, he was part of a history-making expedition in the Galapagos, where he and a team rediscovered the Fernandina Tortoise; a species that had previously thought to have been extinct since 1906. In addition to these history-making findings, Galante continues to search the globe for animals he believes may still be among us including the Rio Apaporis Caiman in Colombia, the Miller's Grizzle Langur, of Borneo, and even the mysterious Pondicherry Shark to name a few.

Galante interacts with a wide range of animals regularly, including sharks; his passion for wildlife began soon after he was born in 1988 when his family moved to Harare, Zimbabwe, from California. He grew up on a productive farm that cultivated luxury alstroemeria flowers, various fruits and was home to a myriad of livestock and wild African animals. As a child, Galante's favorite pastimes included catching snakes, fishing in the dam, breeding guinea pigs and playing rugby. When he wasn't enjoying life on the farm, his mother would take him and his sister on safari in the African bush. As one of Africa's first female safari guides and bush pilots, Galante's mother took her children to explore some of the most remote parts of Africa, collecting artifacts and observing wildlife. Galante was enthralled by all wildlife and knew he would one day pursue a career with animals. At age 14, Galante was the youngest person to ever lead an international canoe safari down the Zambezi River.

Galante returned to the United States in 2001 and later graduated from The University of California at Santa Barbara with a degree in biology; special emphasis in marine biology and herpetology.

Prepared for the US Senate Committee on Environment and Public Works
Legislative Hearing on the Theodore Roosevelt Genius Prize:
Innovative Solutions to Reduce Human-Predator Conflict

Testimony of Forrest Galante,
wildlife biologist, host of Animal Planet's *Extinct or Alive*
and Discovery's Shark Week Special *Extinct or Alive: The Lost Shark*

July 24, 2019

Chairman Barrasso, Ranking Member Carper, and Members of the Committee, thank you for the opportunity to be here today.

I am a wildlife biologist and animal tracker. For as long as I can remember, I have spent as much time as possible looking for wildlife for the experience of seeing them in their natural habitats.

I spent my childhood in Zimbabwe where we lived on a farm. The land was home to flowers, fruits, livestock, and wild animals. As a boy, I enjoyed catching snakes, fishing in the dam, breeding guinea pigs – as well as going out to explore the remote African bush with my mother - one of Africa's first female safari guides and bush pilots. I was enthralled by all wildlife - learning their behavior, how they survive and thrive, and what threatens them and their existence. From a young age, I knew I would pursue a career with animals.

I am honored to be here today to offer my perspective on human-predator conflict and how traditional and technologically innovative techniques can be used to reduce conflicts and benefit humans, wildlife, communities, and habitats. I applaud the Committee's work, especially in recently establishing five Theodore Roosevelt Genius Prizes to look for new ways to prevent wildlife poaching and trafficking; to promote wildlife conservation; to manage invasive species -among others- and potentially a new one to reduce human-predator conflict.

Growing up in Africa, the conflict between predator and human is a daily struggle that I witnessed first-hand - from leopards stealing livestock to people actually being preyed upon by species like crocodiles, lions and more. Unfortunately, in the long term, the predator almost always loses as eradication has typically been the method of resolution. However, especially more recently, innovative methods of predator deterrents have begun to arise. These deterrents, with a very small amount of focus and energy, could easily become the new standard. They will not only resolve the issue but support local economies by keeping the valuable apex predators in the system, which not only helps the biome, but supports ecotourism. The methods I am about to list all tend to be "in development" and have typically been crudely implemented by scientists like myself attempting to resolve a problem with little resources.

The following are non-lethal conflict resolution methods that are a mix of traditional and cutting-edge science.

Relocation - Once an animal has become habituated to eating livestock or dependent on human resources, it is nearly impossible to stop this behavior. This is when relocation becomes necessary. It involves trapping an animal and moving it far away from human presence.

The following examples are methods that avoid the necessity of relocation.

I'll note that understanding animal behavior and ecology of a species leads to coming up with successful deterrents. Just as we know electricity can work to deter sharks, we know based on animal behaviors what will be successful for individual species.

Animatronic Deterrents - In Malawi, there was an infamous hyena that used to raid village flocks constantly. An engineer friend of mine came up with a fascinating animatronic decoy. Because hyenas are scared of large animals, typically fleeing from large men, he designed and built a large motion-activated animatronic scarecrow to place at the entry points of the village. With solar panels to power them, they will scare away any hyenas that come near. This is a permanent fix requiring a bit of engineering to be sustainably successful.

Alarm Systems

1. Foreign- Placing motion activated alarms such as strobing lights and loud sounds is often times enough to scare off anything lurking. Once again, this deterrent can be used on the outskirts of a village or the entry points to a livestock pen. This has proven successful for foxes, coyotes, leopards and more.

2. Organic- Knowing that certain animals fear and flee from others, this method is in my mind, a very simple yet useful one that is underutilized. Certain animals will not invade the territory or kill of another animal. If you have an active leopard problem, the simple solution of playing the growl of a lion will instinctually deter the leopard. Once again this should and would be motion activated, similarly to how a trail camera works.

Olfactory Deterrents - Like the above organic alarm system, an organic smell can often times be enough to deter a predator. Coyotes, for instance, are generally solitary and very territorial. If you have a persistent problem with a coyote, spraying (organic or synthesized) wolf urine around the perimeter can deter the coyotes from entering the area.

Commensalistic Deterrents - In many cases, using an animal to deter another animal has no negative effects at all. This is simply the sheep dog approach. Living in Africa, we would see that a trained packs of Rhodesian ridgeback dogs were a fantastic permanent solution to deterring lions. They stay close to home, create an alarm system and will easily run off a lion that is trying to sneak in for a free meal.

Building Materials - In almost all these cases, we create the encroachment problems that we then need to resolve. A perfect example is with big snakes. In many areas, we leave out old food or use thatched roofs for building materials. Both attract rodents and birds which in turn will attract large species of snakes such as pythons and boas. A simple solution is to use corrugated tin roofing and contain food waste.

Barrier Methods - In many places around the world, fresh water is the reason for predator/prey interactions. In fact, in almost every River Monster's episode on Animal Planet, Jeremey Wade is investigating the disappearance of a person due to them swimming or collecting fresh water. Using cages (like a shark cage) to create safe swimming and washing areas in river systems can eliminate things like crocodile, hippo and even piranha (however rare) attacks.

The list goes on, but the key element here is fully understanding the predator which we are trying to deter.

This point is true for predators in any habitat. There are several new pieces of technology that once properly understood and implemented will be the new standard—including noninvasive shark deterrents, such as "virtual cages" that use sharks specialized electroreceptive abilities. Before wrapping up, I'd like to share a few quick examples:

HECS technology - The HECS technology is a passive technology that blocks the bodies naturally occurring electrical energy. Basically, by wearing a wetsuit that has the technology of a faraday cage (the same thing that's in the door of your microwave oven) it blocks the bodies naturally occurring electrical energy signal. To a shark, you are now perceived more as an inanimate object than prey as you are no longer emitting EMR.

Shark Shield - The shark shield is a light weight wearable electronic device. Shark Shield's patented technology creates a powerful three-dimensional electrical field which causes unbearable spasms in the ampullae of Lorenzini (sharks sensitive EMR receptors) turning sharks away as soon as they come into contact with the electric field.

Clever Buoy - Clever Buoy is an autonomous marine monitoring system developed by Australian company, Smart Marine Systems (SMS). The system is an ocean monitoring platform that specializes in detecting large marine life using state of the art sonar and identification software systems to relay critical information to authorities responsible for beach safety.

Once technology like the clever buoy system is perfected, implemented and combined with something like the shark shield, you have a virtual technological net that can make any beach safe for swimmers, which is just amazing in my opinion! Once you have a populous educated about wearing a technology like the HECs suits, you are likely to see a reduction in encounters with swimmers and divers.

Thank you again for inviting me to be part of today's hearing. I look forward to answering any questions that the committee may have.

Senate Committee on Environment and Public Works
Hearing entitled, *"A Theodore Roosevelt Genius Prize: Innovative Solutions to Reduce Human Predator Conflict"*
July 24, 2019
Questions for the Record for Mr. Galante

Ranking Member Carper:

1. Predators like sharks and bears often get a bad rap. Unfortunately, accounts from the media and the public often demonize these creatures for attacks on humans and livestock, sometimes calling for their complete eradication. Though we should certainly avoid interacting with these predators in the wild, it seems we should also celebrate them as indicators of healthy ecosystems. What role does innovative research and technology play in educating the public about predators? How might technology and science be used to help change public perception and opinion of predators?

   A: I believe public perception is already evolving and understanding of the importance of predators is becoming more widespread. Outreach is key and education is the most important tool. As the science and technology continues to evolve, so will the understanding and the education. Once we can prove that innovative technologies help keep us safe, living side by side with predators, then peoples warped perceptions of the perceived danger, may also change.

2. From acoustic deterrents to motion-activated alarms, there are many innovative, nonlethal technologies available that can help humans avoid unwanted interactions with predators. In your experience, how widespread is the use of these types of nonlethal technologies? What are the barriers currently preventing wildlife managers and the public from using them?

   A: They are slowly becoming more widespread as people begin to understand the importance of maintaining wildlife populations. The problem is a bullet is cheap and effective, most non-lethal deterrents are neither of those yet. But as this science evolves, the methods will become more effective and the cost will come down.

3. Predators do not know boundaries as we do. They move freely from state to state, travel through public and private lands, and swim freely through state and federal waters. It only makes sense, then, that the diverse array of landowners and stakeholders that interact with predators have a hand in shaping conflict avoidance strategies. Would you please elaborate on the role that public participation can play in minimizing human-predator conflicts? Is there anything Congress can do to improve opportunities for public participation in helping different jurisdictions manage these species?

   A: Public participation in supporting these technologies and promoting nonlethal deterrents by utilizing them in private land holdings will make a big difference to the general attitude towards wildlife.

Senator BARRASSO. Thank you so very much.
And now, Dr. Whitney.

STATEMENT OF NICK WHITNEY, SENIOR SCIENTIST AND CHAIR, FISHERIES SCIENCE AND EMERGING TECHNOLOGIES PROGRAM, ANDERSON CABOT CENTER FOR OCEAN LIFE, NEW ENGLAND AQUARIUM

Mr. WHITNEY. Thank you, Chairman Barrasso, Ranking Member Carper, and members of the Committee, for inviting me to testify today on the topic of human-predator conflict as it relates to sharks.

I am a senior scientist and shark researcher at the Anderson Cabot Center for Ocean Life in the New England Aquarium. The New England Aquarium is a catalyst for global change through public engagement, innovative scientific research, and leadership in education and ocean advocacy. Our mission is to conduct research on topics related to ocean health and conservation and develop science based solutions to marine conservation problems.

I personally have studied sharks for over 20 years, and have tagged over a dozen different shark species, including white sharks, tiger sharks, and bull sharks, the three species considered most dangerous to humans.

Although I am a scientist, I am also a husband and father of three young kids, and my heart goes out to the victims and families whenever someone is bitten by a shark. While cold facts and statistics are useless to people who have suffered through these incidents, we owe it to the public to develop our response using the best available science.

The truth about shark bites is that they are incredibly rare. Despite the millions of people that go into the ocean around the world each year, only 66 unprovoked shark bites were recorded globally in 2018, and only 5 of those bites were fatal.

Despite some truly terrible incidents, most shark bites are noteworthy for their lack of severity considering the damage that we know sharks can inflict. In fact, most incidents appear to be cases of mistaken identity or investigatory bites in which a shark uses its teeth to inspect an object and then quickly releases once it realizes that it is not food. Unfortunately, even a tentative bite can cause serious injuries or death, depending on the size and species of the shark involved.

When it comes to conflicts between humans and predators, humans have long had the upper hand. By any measure, we are the deadliest species to have ever existed. Today, we are killing about 100 million sharks a year in global fisheries, with further immeasurable impacts from habitat destruction, pollution, and climate change.

This is unfortunate, because healthy shark populations are extremely valuable to humans. Economically, shark fisheries are valued at over a billion dollars annually, and shark ecotourism may be worth over $300 million globally.

Ecologically, sharks represent a crucial part of the marine ecosystem, the health of which will determine if our planet remains habitable for the 9 billion or more humans expected by 2050, many

of whom are highly dependent on the oceans as their primary source of protein, and at risk from the threats of climate change.

Despite everything we know, people's fear of sharks is amplified and often exploited by news media well aware that scary stories will attract an audience. Innocuous sightings of sharks swimming in the ocean are often accompanied by headlines suggesting vicious attacks, and reports of small, non-threatening shark species are presented along with pictures of white sharks attacking seals.

In the United States, the most recent area of media focus has been on the growing number of white shark sightings around Cape Cod, Massachusetts, where there have been five shark bites on humans since 2012, including a tragic fatality in 2018 that was the State's first shark related death in over 80 years.

The increase of white shark presence along the Cape is thought to be driven largely by the growing population of grey seals, which are a preferred prey item for white sharks. In response to these increased sightings, the Massachusetts Division of Marine Fisheries and the Atlantic White Shark Conservancy have been conducting research to understand shark movements and inform public safety strategies.

Starting this year, the New England Aquarium is joining the team to apply the latest in high tech tagging technology to understand these sharks' fine scale behaviors, as well as the nature and frequency of white shark feeding events on seals. I brought a few of those tags here.

In the meantime, towns across the Cape have been working with the Conservancy and the Massachusetts Division of Marine Fisheries to raise awareness about sharks through community engagement and outreach. Research information is shared in a two-way conversation with the public through the Conservancy's Sharktivity smart phone app, as well as on the group's Web site. This implementation of cutting edge scientific research, in conjunction with public outreach and education programs, is likely the most effective way to ameliorate the impact of shark-human conflicts.

Although it is tempting to reach for quick solutions to prevent shark bites, any new technologies claiming to be a one size fits all solution run the risk of giving people a false sense of security and should therefore be subjected to rigorous scientific testing before being broadly implemented. In addition to what is being proposed today, sustained funding for scientific research is the key to achieving the depth of knowledge required to sustainably manage our ocean resources and to produce effective new tools and strategies to avoid conflicts between humans and sharks.

Thank you.

[The prepared statement of Mr. Whitney follows:]

Nick Whitney, Ph.D.
Senior Scientist and Chair
Anderson Cabot Center for Ocean Life

Dr. Whitney is a Senior Scientist and Chair of the Fisheries Science and Emerging Technologies Program at the Anderson Cabot Center for Ocean Life at the New England Aquarium. He jointly serves as a Senior Research Scientist at the Newport Aquarium in Kentucky. From 2009-2016, he worked as a Postdoctoral Scientist and then Staff Scientist at Mote Marine Laboratory in Florida.

Dr. Whitney has studied sharks in the wild for over 20 years and has personally tagged over a dozen shark species, including the top three species implicated in attacks on humans. His work focuses on the use of cutting-edge technology to answer important questions for species conservation and natural resource management. He is currently studying the movement and behavior of sharks, fish, and sea turtles using novel accelerometer and camera tags.

He has published numerous scientific papers, popular magazine articles, and shark articles for World Book Encyclopedia Online, and has appeared on the History Channel, Discovery Channel, and National Geographic Channel.

Dr. Whitney received a bachelor's degree in biology from Albion College (Michigan) in 2000 and a master's degree and Ph.D. in zoology from the University of Hawaii in 2007 and 2009, respectively.

Written Testimony of

Dr. Nick Whitney
Senior Scientist and Chair
Fisheries Science and Emerging Technologies Program
Anderson Cabot Center for Ocean Life
New England Aquarium

Before the Senate Committee on Environment and Public Works

Hearing on "Theodore Roosevelt Genius Prize: Innovative Solutions to Reduce Human-Predator Conflict"

July 24th, 2019

Thank you to Chairman Barrasso and Ranking Member Carper for inviting me to testify on the topic of human-predator conflict as it relates to sharks. I am Senior Scientist and Chair of the Fisheries Science and Emerging Technologies (FSET) Program in the Anderson Cabot Center for Ocean Life at the New England Aquarium. The New England Aquarium is a catalyst for global change through public engagement, innovative scientific research, commitment to marine animal conservation, leadership in education, and effective advocacy for vital and vibrant oceans. Our mission is to conduct research on topics related to ocean health and conservation and to develop science-based solutions to marine conservation problems. Specifically, the FSET program has a strong background in utilizing cutting-edge technology to answer important fisheries questions, and sharks are one of its primary areas of focus.

I have studied sharks for over 20 years, starting as an undergraduate at Albion College in Michigan where I spent my summers assisting with a study of nurse sharks (*Ginglymostoma cirratum*) in the Florida Keys. I then spent eight years studying sharks in Hawai'i while earning a Masters degree and Ph.D. in Zoology at the University of Hawai'i at Manoa. I completed postdoctoral research and served as a Staff Scientist at Mote Marine Laboratory in Sarasota, Florida before joining the New England Aquarium (Boston, Massachusetts) and Newport Aquarium (Newport, Kentucky) in a joint appointment. I have published numerous peer-reviewed scientific papers as well as popular shark articles in magazines and the World Book Encyclopedia Online and have also appeared in various television documentaries on sharks. Over the course of my career I have tagged and studied over a dozen shark species, including the three species considered most dangerous to humans: the white shark (also known as the "great white shark," *Carcharadon carcharius*), the tiger shark (*Galeocerdo cuvier*), and the bull shark (*Carcharhinus leucas*).

Shark attacks on humans are tragic events that can have life-altering consequences for the victims, their families, and the community. Although fatalities are rare, averaging 4–6 per year globally, sharks bites can cause lasting injuries that require multiple surgeries and years of rehabilitation for recovery. While it is important to process these incidents in the broader context of science, shark behavior, and public perception, the impact of these incidents on victims cannot be overstated.

The history of human-predator conflict

Conversations about human-predator conflict should note that, from the time of the earliest humans, such "conflicts" have been incredibly one-sided. By virtually any measure, humans are the deadliest animal species that has ever existed. An examination of the fossil record around the world reveals a pattern that repeats itself over and over again: first humans arrive in a new region, then other large animals quickly disappear from that region. We have been so effective at eradicating large animals from early on in our species history that a recent summary concluded that our species "drove to extinction about half of the planet's big beasts long before [we] invented the wheel..." (Harari 2015).

The impact of human-predator conflict on sharks

While marine animals were largely spared eradication by prehistoric humans, technological developments over the past century allowed us to exploit marine resources at a rapid and unsustainable pace. For sharks, this has resulted in the slaughtering of ~100 million animals per year (Clarke et al. 2006). Much like the giant sloths and wooly mammoths we drove to extinction thousands of years ago, sharks are often slow-growing, long-lived organisms that produce relatively few offspring (Musick et al. 1999).

For instance, white sharks, including those swimming off of Cape Cod, Massachusetts, must survive for 26–33 years before they are old enough to start reproducing, and they may live to be over 70 years old if they are not killed by humans (Natanson and Skomal 2015). Once they reach maturity, a female white shark may produce only 7–14 offspring every one to three years (Francis 1996) as opposed to the millions of eggs that can be produced annually by many other fish species. This life strategy has served sharks well throughout their long evolutionary history, but is poorly-suited to withstand fishing pressure from humans. This is because, once the targeted adults are removed from a population, it can take decades for the surviving juveniles to reach maturity and start rebuilding the population. For this reason, shark fisheries have historically shown "boom and bust" patterns, marked by a rapid increase in catch rates at the start of a fishery, followed by rapidly falling catch rates, and collapse of the fishery shortly thereafter. Today approximately one quarter of the world's sharks and rays (close relatives to sharks) are threatened with extinction (Dulvy et al. 2014), with overfishing being the primary driver of population declines, followed by factors related to habitat loss and climate change.

Climate change is already impacting shark populations and may very well impact human-shark conflicts in prominent ways. Most sharks are ectothermic or "cold-blooded," meaning that their body temperature is the same as the water in which they swim. Warming water temperatures will increase a shark's body temperature thereby increasing its metabolic rate, causing it to burn calories faster, and requiring more food to replace those calories.

What we commonly see in sharks is a relatively narrow range of preferred temperatures, and animals will migrate seasonally to stay within that range. We are already seeing signs of temperature-related changes in shark populations on the East Coast, with several shark species being found further north than what has been historically observed. For instance, a recent study showed that bull sharks have established a nursery in Pamlico Sound, North Carolina over the past eight years whereas their northernmost nursery had historically been the Indian River Lagoon, Florida (Bangley et al. 2018). Also, the large migration of blacktip sharks (*Carcharhinus limbatus*) that makes headlines every year off the coast of

South Florida is known to be driven by water temperature (Castro 1996; Kajiura and Telman 2016), with some indications that this species is shifting northward.

The demonization of sharks in the modern media

Efforts to reduce human impacts on shark populations are hampered by the portrayal of sharks in modern media. Although the public image of sharks has improved substantially since the days of *Jaws*, the news media and popular television shows frequently cover shark incidents in the most sensational terms possible. Public fear of sharks can reliably draw readers and viewers on an otherwise slow news day, even when there hasn't been a shark incident. Television documentaries often feature staged attack re-enactments edited to look like authentic video footage of the original incident, then try to balance their messaging with a couple of sentences about shark conservation at the end of the show. With few exceptions, media coverage of shark bites or even shark sightings continues to be inflammatory and sometimes completely inaccurate regarding basic things such as species identification or descriptions of behavior.

Why humans need sharks

All of this is unfortunate because healthy shark populations are extremely valuable to humans. Economically, commercial shark fisheries are valued at over $1 billion annually when accounting for products that countries consume domestically (Dent et al. 2015; Dulvy et al. 2017), and shark eco-tourism may be worth over $300 million globally (Cinseros-Montemayor et al. 2013). This does not account for the value sharks provide as part of the recreational fishing industry, which is estimated to contribute $125 billion per year in the United States alone according to the American Sportfishing Association.

As apex predators, sharks may have a disproportionate impact on the rest of the food chain. There is evidence suggesting that removing top-level predators causes a "trophic cascade," meaning that the impacts cascade down through lower levels of the ecosystem (Stevens et al. 2000; Ferretti et al. 2010). For example, removing sharks from coral reef ecosystems can lead to overpopulation of mid-level predators, which then causes a dramatic reduction in the population of lower-level, algae-grazing fish species. Depletion of these species allows algae to overgrow the reef, killing the corals that build the reef itself (Bascompte et al. 2005). Sharks also play an oversized role in affecting the marine ecosystem through "indirect effects," such as affecting the behavior and distribution of large prey species (Heithaus et al. 2012).

Sharks represent a crucial part of the marine ecosystem, the health of which will determine if our planet remains habitable for the nine billion or more humans expected by 2050—many of whom are at risk and vulnerable. In addition to producing half of the world's oxygen and feeding billions of people, the ocean absorbs about 25% of the carbon dioxide and has taken up more than 90% of the heat added to the planet by humans (USGCRP 2018).

The Science of Shark "Attacks"

Although shark bites on humans are extremely tragic and can cause bodily injury and even death, these incidents are difficult to study and thus predict/prevent because of their rarity. The International Shark Attack File (ISAF) recorded a total of only 66 confirmed

unprovoked incidents across the entire world in 2018, five of which were fatal. The United States accounted for 32 of these 66 incidents, with half (16) of those taking place in the state of Florida. Other states with incidents included Hawai'i, North Carolina, and South Carolina (3 incidents each), New York and Massachusetts (2 incidents each, one fatal), and three other states (California, Georgia, and Texas) with a single incident each.

Although statistically humans have more to fear from dogs, cattle, and insects than they do from sharks, for most people in developed countries, sharks are the last remaining natural predators they may encounter. This, and the fact that sharks are usually invisible and undetected until the moment of a bite, may be why they inspire so much fear and interest in modern society.

In reality, shark bites on humans usually lack the passion and ferocity depicted in attack re-enactments on television, or that one might expect from a charging grizzly bear. This is not to diminish those instances of rare, but deadly, shark incidents—but the vast majority of shark bites on humans are likely "investigatory bites" in which a shark uses its mouth in an attempt to identify an unknown object, much the way humans might use our hands to examine something new. Sharks are capable of surprising dexterity with their mouths and teeth, frequently biting each other during mating, for instance, without causing serious damage (e.g., Pratt and Carrier 2001; Whitney et al. 2004). Further evidence for this lies in the clean puncture wounds seen on many shark bite victims, with no evidence of a stronger bite or head-shaking behavior that would be expected if the shark was trying to remove tissue. Although even these "bite and release" events can produce serious and devastating injury, they are often notable for their lack of severity given sharks' capabilities.

For this reason, most shark scientists now refer to shark "bites," rather than shark "attacks," and the American Elasmobranch Society, the world's largest group of shark scientists, has adopted a resolution calling for the Associated Press Stylebook and the Reuters Style Guide to do the same (Neff and Hueter 2013).

Other bites may take place when sharks are already in a feeding behavioral mode, perhaps because there are baitfish, seals, or other natural prey nearby and humans are mistaken for prey. In these instances, sharks are likely to behave far more aggressively. The best way to avoid these situations is to be aware of one's surroundings and avoid areas where baitfish are aggregating (often visible from fish jumping or sea birds overhead), where people are fishing or cleaning fish, areas near river mouths that may carry dead animals and other prey, or areas near known seal haulouts.

There is no evidence that supports the persistent—yet false—belief that sharks are territorial and will defend an area from other sharks or other animals for any period of time. While certain sharks will commonly "give way" to other (usually larger) sharks when they encounter each other, this does not equate to territoriality. In fact most large sharks are highly migratory and can move hundreds of miles in a matter of days. Although virtually every part of the world where humans encounter sharks has local stories of an individual shark (usually nicknamed) that "patrols" a specific area, further investigation almost always reveals that multiple sharks are moving in and out of the area frequently. There have been cases of sharks showing fin- and body-flexing postures and even biting when pursued by humans, but this is exceptionally rare and seems to happen when a human has followed the shark for an extended period or cornered it.

This leads to perhaps the most common way that people are injured by sharks, which is through "provoked attacks." The ISAF reported 34 provoked incidents globally in 2018 (compared to 66 unprovoked), but the vast majority of these likely go unreported. Sharks are intelligent predators that easily learn to associate certain stimuli or locations with food. Most fishing piers in the world likely have sharks nearby that have habituated to feeding on discarded catch or carcasses. Spearfishers commonly report sharks approaching in response to the sound of an underwater speargun being fired, even before any fish have been speared. These and other human activities greatly increase the likelihood of being bitten, and thus "provoked incidents" include bites on fishermen, people attempting to feed sharks, or divers that have tried to touch or harass sharks. Unfortunately, shark scientists engage in some of these behaviors by the nature of our work, and the various shark bites that I have been witness to or a "victim" of have all fallen under this provoked category.

White sharks around Cape Cod

Regarding shark-human interactions in the United States, the most recent area of focus has been in New England and the growing number of white shark sightings near the shores of Cape Cod, Massachusetts. This situation has been brought to light by five shark bites on humans in the area since 2012, including a fatality in 2018 that was the state's first shark-related death since 1936. The increase in white shark presence along the Cape is thought to be driven largely by the growing population of grey seals (*Halichoerus grypus*) that had been decimated in the area but started recovering after passage of the Marine Mammal Protection Act in 1972. Seals are a preferred prey item for white sharks, which are also showing signs of population growth since receiving protection in federal waters in 1997, and Massachusetts state waters in 2005 (Skomal et al. 2012; Curtis et al. 2014), though stock status is uncertain.

Overall the recovery of Atlantic white sharks and grey seals is considered a wildlife management success story, but one that has increased the likelihood of human conflicts with wildlife. In response to this, the Massachusetts Division of Marine Fisheries (MA DMF) has been conducting white shark research to understand increased shark activity and inform shark safety strategies. Starting in 2019, MA DMF partnered with the Atlantic White Shark Conservancy (AWSC) and the New England Aquarium to apply the latest in high-tech shark tag technology to quantify the nature and frequency of white shark feeding events on seals.

In the meantime, towns across Cape Cod and the South Shore, the Cape Cod National Seashore, the AWSC, and MA DMF have been working to raise awareness through community engagement and outreach. Research information is shared with safety officials, residents, and visitors so that decisions can be made using the best available data. See AWSC's public safety page for more info: https://www.atlanticwhiteshark.org/public-safety

Local officials are also working to increase the frequency of medical stations along Cape Cod beaches, since the biggest risk to shark bite victims is blood loss following the incident. Most fatalities happen once the victim has reached the beach but before they can receive expert medical aid to stop the bleeding. This may not appeal to residents who are looking for a "solution" to human-shark interactions, but it is likely the quickest, most effective way to minimize loss of life.

Although extensive shark research is ongoing, the best near-term solution is to focus on educating and changing the attitudes of humans who use the ocean. The Cape Cod National Seashore is a National Park and should be thought of like other prominent National Parks such as Yellowstone or Yosemite where humans can also encounter predators. These are national treasures where people can enjoy the sights and the wildlife, but where personal safety is not guaranteed and visitors must take proper precautions.

What can be done?

The increased risk of shark bites around Cape Cod has elicited an understandable desire for a "solution" to the problem from the local community and their representatives. Shark bite mitigation is an emotionally-charged issue that has produced multiple responses in various parts of the world.

Some of the earliest human responses to attacks in the 20th century were "shark hunts"—disorganized efforts to fish for and catch the culprit shark in the days immediately following an incident (Curtis et al. 2012). Such efforts were based on the now debunked assumptions that sharks were territorial and could develop a preference for hunting humans and that a culprit shark could and should be caught after an incident.

From 1959 through the early 1970's, the State of Hawai'i funded a number of large-scale shark culling programs in response to a series of bites including a high-profile fatality. Over 4000 sharks were caught and killed using baited longlines in these programs, but only ~12% of these were tiger sharks, the species responsible for nearly all shark attacks in Hawai'i state waters (Wetherbee et al. 1994). Inconsistency in the sampling methodology and seasonality make it difficult to determine whether these programs significantly reduced shark populations in the state, and they were found to have no effect in reducing the number of shark bites (Wetherbee et al. 1994).

For decades, some countries have utilized shark control programs involving the permanent deployment of nets or other fishing gear to catch and kill sharks that approach swimming beaches (reviewed by Curtis et al. 2012). The largest of these programs are based around discrete beaches in New South Whales and Queensland, Australia and off the KwaZulu-Natal province of South Africa. Nets and baited lines in these areas are not deployed to repel sharks but with the intent to reduce the population of large sharks in the area and thereby reduce the likelihood of shark-human interactions. These programs have been successful in substantially reducing the number of shark bites on humans in these areas, but they do not eliminate the risk completely (Curtis et al. 2012). Such programs are also expensive to maintain and have a high ecological cost since the nets kill large numbers of sharks as well as other marine life such as large fishes, sea turtles and marine mammals. For this reason, recently introduced shark culling programs off the coast of Western Australia have been highly controversial and met with public outcry.

Physical barriers to prevent sharks from entering beaches have been utilized in some parts of the world but are expensive to maintain and often logistically impossible due to the broad area that must be protected, and the constant threat of structural damage from wind, waves, and corrosion.

The costs associated with shark control fishing and physical barriers has led other communities to turn to increased beach surveillance, with the most notable example being

the Shark Spotters program in Cape Town, South Africa. Here a small staff of human spotters are employed at strategic locations overlooking the beach and send warnings when a shark is sighted, allowing lifeguards to clear swimmers from the water. This program is accompanied by a beach flag notification system and an extensive public outreach campaign to educate ocean users about the presence of sharks and best practices for avoiding shark incidents (Engelbrecht et al. 2017).

Public outreach and biological research

The implementation of public outreach and education programs, in conjunction with basic scientific research, is likely the most effective way to ameliorate the impact of shark-human conflict. For instance, shark hunts or state-funded culling have not been implemented in Hawai'i since research showed that the main species responsible for these bites, tiger sharks, are wide-ranging and often move between islands within a 24-hour period (Holland et al. 1999). This work demonstrated that trying to catch a "culprit shark" after a bite was a fruitless endeavor. A more recent study there has shown that tiger shark reproductive patterns and use of habitat around human recreational sites is responsible for an increased likelihood of incidents around the island of Maui compared to Oahu (Meyer et al. 2018).

Published and ongoing research on white sharks in Cape Cod waters using electronic tags and photo-identification has elucidated the seasonal movements of this species (Skomal et al. 2017). Further work is underway using high-tech accelerometer (Whitney et al. 2018) and camera (Papastamatiou et al. 2018) tags to quantify their feeding behavior on seals. Such information will be shared directly with the public in collaboration with the AWSC and the New England Aquarium.

To that end, the AWSC's "Sharktivity" smartphone app is a powerful example of using technology to integrate basic research with public outreach. This app provides up-to-date information on the group's work tagging and tracking white sharks in the area while also allowing members of the public to submit their own shark sightings via photographs and videos. This technology disseminates research findings and encourages users to get to know individual sharks through their movements, demystifying them while also raising awareness of their presence. Shark tracking websites and apps from other institutions—most notably the non-profit group Ocearch—are also proving effective at engaging the public on these issues.

Research provides crucial information about the biology and behavior of these species that, when effectively communicated to the public, can reduce the fear factor and allow people to make informed decisions about their own use of the ocean.

Importance of innovation in discovery-driven research

The New England Aquarium has a long and robust history of conducting discovery-based scientific research that informs decision-making in support of responsible management of ocean resources. Our scientific research is cutting edge and relies on emerging technologies, big data, and predictive modeling to understand marine species that are inherently difficult to study from the surface. Studying these species is critically important to managing human impacts on the ocean and to working towards balancing human needs with ecosystem needs.

Like other scientific institutions across the United States, federal funding provides critical support to The New England Aquarium's research programs. In recent years, challenges and prizes have gained in popularity as an instrument for encouraging innovation and, if administered effectively, have the potential to accelerate technology development and increase the diversity of participants (individuals, teams, or organizations) addressing a given challenge.

While technology and innovation have an important role in enabling scientists to develop a greater understanding of predators, prey, and how they are interlinked, they have also enabled humans to become more effective predators ourselves.

Scientific research underpins our understanding of the natural world. It can also inform best practices to minimize the impacts that humans have on the planet and to achieve balance between human activities and the ecosystems that sustain life on Earth. The recent U.N. biodiversity study found that one in four species is at risk of extinction and further asserts that human activities are the cause (IPBES 2019). As the most intelligent and deadliest predator the world has ever known, the responsibility to prevent the majority of these conflicts lies with us.

References

Bangley, C.W., Paramore, L., Shiffman, D.S., and Rulifson, R.A. 2018. Increased Abundance and Nursery Habitat Use of the Bull Shark (Carcharhinus leucas) in Response to a Changing Environment in a Warm-Temperate Estuary. Sci. Rep. **8**:6018. doi:10.1038/s41598-018-24510-z.

Bascompte, J., Melian, C.J., Sala, E. 2005. Interaction strength combinations and the overfishing of a marine food web. Proceedings of the National Academy of Sciences of the United States of America 102: 5443-5447.

Castro, J.I. 1996. Biology of the blacktip shark, *Carcharhinus limbatus*, off the southeastern United States. Bull. Mar. Sci. **59**:508–522.

Cisneros-Montemayor, A.M., Barnes-Mauthe, M., Al-Abdulrazzak, D., Navarro-Holm, E., and Sumaila, U.R. 2013. Global economic value of shark ecotourism: implications for conservation. Oryx 47, 381–388.

Clarke, S.C., McAllister, M.K., Milner-Gulland, E.J., Kirkwood, G.P., Michielsens, C.G.J., Agnew, D.J., Pikitch, E.K., Nakano, H., and Shivji, M.S. 2006. Global estimates of shark catches using trade records from commercial markets. Ecol. Lett. **9**:1115–1126. doi:10.1111/j.1461-0248.2006.00968.x.

Curtis, T.H., Bruce, B.D., Cliff, G., Dudley, S.F.J., Klimley, A.P., et al. 2012. Responding to the risk of white shark attack: updated statistics, prevention, control methods, and recommendations. In: Global perspectives on the biology and life-history of the white shark. (eds Domeier). CRC Press. p. 477–510.

Curtis, T.H., McCandless, C.T., Carlson, J.K., Skomal, G.B. et al. 2014. Seasonal distribution and historic trends in abundance of white sharks, *Carcharodon carcharias*, in the western North Atlantic Ocean. PLOS ONE 9:e99240.

Dent, F., and Clarke, S.C. 2015. State of the global market for shark products, Volume 590 (Rome: Food and Agriculture Organization of the United Nations).

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M., Harrison, L.R., Carlson, J.K., Davidson, L.N., Fordham, S. V, Francis, M.P., et al. 2014. Extinction risk and conservation of the world's sharks and rays. Elife **3**. doi:10.7554/eLife.00590.

Dulvy, N.K., Simpfendorfer, C.A., Davidson, L.N.K., Fordham, S. V., Bräutigam, A., Sant, G., and Welch, D.J. 2017. Challenges and Priorities in Shark and Ray Conservation. Curr. Biol. **27**:R565–R572. doi:10.1016/j.cub.2017.04.038.

Engelbrecht, T., Kock, A., Waries, S., & O'Riain, M. J. 2017. Shark Spotters: Successfully reducing spatial overlap between white sharks (*Carcharodon carcharias*) and recreational water users in False Bay, South Africa. PLOS ONE, 12(9), e0185335.doi:10.1371/journal.pone.0185335

Ferretti, F., Worm, B., Britten, G.L., Heithaus, M.R., Lotze, H.K. 2010. Patterns and ecosystem consequences of shark declines in the ocean. Ecology letters 13: 1055-1071.

Francis, M.P. 1996. Observations on a pregnant white shark with a review of reproductive biology. In: Klimley, A.P., Ainley, D.G., editors. The biology of the white shark, *Carcharodon carcharias*. Academic Press, San Diego, CA, p. 157-172.

Harari, Y. N. 2015. Sapiens: A brief history of humankind. HarperCollins Publishers, New York, NY. 414 pgs.

Heithaus, M.R., Wirsing, A.J., and Dill, L.M. 2012. The ecological importance of intact top-predator populations: a synthesis of 15 years of research in a seagrass ecosystem. Marine and Freshwater Research. 63, p. 1039–1050.

Holland, K.N., Wetherbee, B.M., Lowe, C.G., and Meyer, C.G. 1999. Movements of tiger sharks (*Galeocerdo cuvier*) in coastal Hawaiian waters. Mar. Biol. **134**:665–673. doi:10.1007/s002270050582.

International Shark Attack File. 2018 Yearly Worldwide Shark Attack Summary. Florida Museum of Natural History. https://www.floridamuseum.ufl.edu/shark-attacks/yearly-worldwide-summary/

IPBES. 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services. Brondizio, E.S., Settele, J., Díaz, S., Ngo, H.T., editors. IPBES Secretariat, Bonn, Germany.

Kajiura, S.M., and Tellman, S.L. 2016. Quantification of massive seasonal aggregations of blacktip sharks (*Carcharhinus limbatus*) in Southeast Florida. Patterson HM, editor. PLoS One **11**:e0150911. doi:10.1371/journal.pone.0150911.

Meyer, C.G., Anderson, J.M., Coffey, D.M., Hutchinson, M.R., Royer, M.A., and Holland, K.N. 2018. Habitat geography around Hawaii's oceanic islands influences tiger shark (Galeocerdo cuvier) spatial behaviour and shark bite risk at ocean recreation sites. Sci. Rep. **8**:4945. doi:10.1038/s41598-018-23006-0.

Musick, J.A. 1999. Ecology and conservation of long-lived marine animals. In: Musick, J.A., editor. Life in the slow lane: ecology and conservation of long-lived marine animals. Bethesda, Maryland: American Fisheries Society Symposium, Bethesda, MD, p. 1–10.

Natanson, L.J., and Skomal, G.B. 2015. Age and growth of the white shark, Carcharodon carcharias, in the western North Atlantic Ocean. Mar. Freshw. Res. **66**:387. doi:10.1071/MF14127.

Neff, C., and Hueter, R. 2013. Science, policy, and the public discourse of shark "attack": a proposal for reclassifying human–shark interactions. J. Environ. Stud. Sci. **3**:65–73. doi:10.1007/s13412-013-0107-2.

Papastamatiou, Y.P., Meyer, C.G., Watanabe, Y.Y., Heithaus, M.R. 2018. Animal-borne video cameras and their use to study shark ecology and conservation. In: Carrier, J.C., Heithaus, M.R., Simpfendorfer, C.A., editors. Shark Research: Emerging Technologies and Applications for the Study of Shark Biology. CRC Press. Boca Raton, FL. p. 83-92. ISBN 978-1138-03297.

Pratt, H.L., and Carrier, J.C. 2001. A review of elasmobranch reproductive behavior with a case study on the nurse shark, *Ginglymostoma cirratum*. Environ. Biol. Fishes **60**:157–188. doi:10.1023/A:1007656126281.

Skomal, G., Braun, C., Chisholm, J., and Thorrold, S. 2017. Movements of the white shark Carcharodon carcharias in the North Atlantic Ocean. Mar. Ecol. Prog. Ser. **580**:1–16. doi:10.3354/meps12306.

Skomal, G.B., Chisholm, J., Correia, S.J. 2012. Implications of increasing pinniped populations on the diet and abun- dance of white sharks off the coast of Massachusetts. In: Domeier, M.L., editor Global perspectives on the biology and life history of the white shark. CRC Press, Boca Raton, FL, p. 405–418

Stevens, J.D., Bonfil, R., Dulvy, N.K., and Walker, P. (2000). The effects of fishing on sharks, rays and chimaeras (Chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science. 57, p. 476–494.

USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

Wetherbee, B.M., Lowe, C.G., and G.L. Crow. 1994. A review of shark control in Hawaii with recommendations for future research. Pacific Science 48: 95-115.

Whitney, N.M., Lear, K.O., Gleiss, A.C., Payne, N., White, C.F. 2018. Advances in the application of high-resolution biologgers to elasmobranch fishes. In: Carrier, J.C., Heithaus, M.R., Simpfendorfer, C.A., editors. Shark Research: Emerging Technologies and Applications for the Study of Shark Biology. CRC Press. Boca Raton, FL. p. 45-69. ISBN 978-1138-03297.

Whitney, N.M., Pratt, H.L., Carrier, J.C. 2004. Group courtship, mating behaviour, and siphon sac function in the whitetip reef shark, Triaenodon obesus. Animal Behaviour 68: 1435-1442.

Senate Committee on Environment and Public Works
Hearing entitled, *"A Theodore Roosevelt Genius Prize: Innovative Solutions to Reduce Human Predator Conflict"*
July 24, 2019
Questions for the Record for Mr. Whitney

Ranking Member Carper:

1. *Predators do not know boundaries as we do. They move freely from state to state, travel through public and private lands, and swim freely through state and federal waters. It only makes sense, then, that the diverse array of landowners and stakeholders that interact with predators have a hand in shaping conflict avoidance strategies. Would you please elaborate on the role that public participation can play in minimizing human-predator conflicts? Is there anything Congress can do to improve opportunities for public participation in helping different jurisdictions manage these species?*

This question highlights one of the biggest challenges that we face in managing ocean resources in general, and particularly highly migratory species like sharks. Even coastal shark species frequently use waters of multiple states and nations, and pelagic species usually occupy international waters offshore where they can be targeted with minimal, if any, oversight. While the ocean is far too large for us to monitor with direct surveillance, sharks and other harvested resources are brought in to port eventually, and this is where our conservation and management efforts must focus.

Although we have had inadequate oversight producing "boom and bust" fisheries cycles in the past, U.S. shark fisheries in 2019 are the most sustainably-managed shark fisheries in the world. This fact gives us great leverage in pressuring other nations to raise their fisheries management to our standards through organizations such as the Food and Agriculture Organization (FAO), the International Union for Conservation of Nature (IUCN), and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). These international efforts are supported not only by conservationists but often by our domestic commercial fishing industry, since they share the resource with other nations who may not have to play by the same rules.

In making the case for responsible fisheries management in an international forum, the biggest challenge is often a lack of empirical data on the basic biology of the species in question. One area where Congress could make a crucial impact here is to continue and expand funding for marine fisheries research through the National Oceanic and Atmospheric Administration. Federal funding mechanisms for this type of work are in short supply, and the ones that do exist are woefully inadequate for collecting the amount of information we need to address the threats facing our oceans today.

Obtaining accurate, empirical data on predator populations and then disseminating that information is the best way to encourage informed and productive public participation in these issues.

2. *Although the majority of shark bites to humans are unprovoked, approximately 1/3 of the global total of shark bites to humans in 2018 were classified as 'provoked.' This means that a human initiated interaction with a shark in some way prior to the bite, such as by harassing or trying to touch sharks. I understand that some sharks, including nurse sharks, display interesting behavior when provoked. In your experience, how do nurse sharks and others species that you have studied behave when they are provoked? Would any tagging technologies or other technologies be able to prevent provoked bites?*

Nurse sharks are one of least aggressive shark species and yet have a surprising number of bites reported on humans. This is because they are so passive that humans are tempted to grab them by the tail and handle the sharks in order to show off to other humans. In most of these cases the nurse shark, almost always a small juvenile, will bite the offending human on the nearest appendage and refuse to let go. This is a highly adaptive response, since attaching yourself to the body of a predator is a good way to avoid being eaten by that predator. Unfortunately the brave human, usually male, tends to lose their courage at this point and often ends up "wearing" the shark to the emergency room to be removed by a doctor. Unfortunately this cowardly act ends in the shark's demise. Through our experience (we have been bitten while capturing nurse sharks for research purposes) we have learned that leaving the sharks in the water and removing all pressure from them will cause them to release their bite and swim away on their own within 1-2 minutes. Nurse sharks have relatively small teeth and will leave behind a bloody bruise, but otherwise do not require medical attention.

Unfortunately the only way that technology can help these provoked attacks is by improving public awareness and education. For instance, I often highlight these stories when they are posted on social media and point out the appropriate way to respond when a baby nurse shark becomes attached to you.

Senator Whitehouse:

3. *Is there a need for increased funding to support sustained research programs?*

There is definitely a need for increased funding to support sustained research programs to study sharks and many other issues confronting our oceans and our planet. Most shark species are slow-growing, long-lived organisms that produce relatively few offspring and require long-term monitoring to ensure their populations are being managed responsibly. This makes sharks exceptionally vulnerable to fishing pressure, and also means that understanding trends in shark populations takes much longer than a typical 12-month grant.

This is extremely important since, economically, shark fisheries are valued at over $1 billion annually and shark eco-tourism may be worth over $300 million globally. This does not include the potential value of sharks for cures to human diseases and infection. Sharks almost never get cancer and their immune system may hold secrets to defeating certain types of cancers in humans. Sharks are also highly resistant to infection and a broad range of antibiotic substances has been found in the skin mucus of sharks and rays. In fact the Department of Defense is currently funding researchers in the U.S. to study whether any of these substances can be used to

develop new antibiotics that could be used to treat our wounded warriors on the battle field.

Perhaps most importantly, sharks represent a crucial part of the marine ecosystem with a disproportionately large impact on the rest of the food chain. There is evidence suggesting that removing top-level predators causes a "trophic cascade," meaning that the impacts cascade down through lower levels of the marine ecosystem. The health of this marine ecosystem will determine if our planet remains habitable for the nine billion or more humans expected by 2050—many of whom are highly dependent on oceans as their primary source of protein and at risk from the threats of a changing climate.

4. *A 2013 paper (Marine Policy 40 (2013): 194-204) states that humans kill approximately 100 million sharks per year. In the U.S., sharks kill someone about once every two years. Cows kill about 20 people per year. Why do you think we are so fascinated by shark attacks when they are relatively unlikely, and when we do much more harm to them than they do to us?*

It is absolutely correct that the conflict between humans and sharks is incredibly one-sided in humans' favor and yet our seemingly irrational fear of sharks persists. Humans are probably evolutionary adapted to pay close attention to anything that poses an immediate existential threat. Our brains and bodies evolved under conditions in which predators were one of the main threats to our survival, and we are therefore "hard-wired" to be extremely sensitive to their presence. Although in Western societies humans have eradicated most large predators from the areas where we spend our daily lives, millions of people every year still enter the oceans in areas inhabited by sharks. Thus for most Americans and citizens of developed nations, sharks are the last remaining wild predator that they have any real chance of encountering.

5. *How does climate change drive human-predator conflicts?*

    a. *If we do not take strong action on climate change, what should we expect to see?*

Climate change is already impacting shark populations and may very well impact human-shark conflicts in prominent ways. Most sharks are ectothermic or "cold-blooded," meaning that their body temperature is the same as the water in which they swim. Warming water temperatures will increase a shark's body temperature thereby increasing its metabolic rate, causing it to burn calories faster, and requiring more food to replace those calories.

What we commonly see in sharks is a relatively narrow range of preferred temperatures, and animals will migrate seasonally to stay within that range. We are already seeing signs of temperature-related changes in shark populations on the East Coast, with several shark species being found further north than what has been historically observed. For instance, a recent study showed that bull sharks have established a nursery in Pamlico Sound, North Carolina over the past eight years whereas their northernmost nursery had historically been the Indian River

Lagoon, Florida. Also, the large migration of blacktip sharks (*Carcharhinus limbatus*) that makes headlines every year off the coast of South Florida is known to be driven by water temperature, with some indications that this species is shifting northward.

If we do not take strong action on climate change, we should expect to see continuing rises in sea level and warming sea surface temperatures, producing changes in the distribution of sharks and many other species with consequences that are impossible to predict. One likely scenario that may already be occurring is that sharks will venture further north and closer to shore in greater numbers than what we are accustomed to seeing along our East coast. This may very well increase the potential for human-shark conflict.

Senator BARRASSO. Thanks to all of you for your testimony. Very interesting.

I will just start with some questions I wanted to start with. This past weekend, on Sunday, I was in Buffalo, Wyoming, where it was Longmire Days. He is a sheriff in books by Craig Johnson.

There is another equally famous officer from Wyoming, another fictional character that C.J. Box writes about, Joe Pickett, who was a game warden for many years.

You were a game warden for 20 years. Anybody that were to sit there and Google Joe Pickett detective series, the guy there in the picture looks like it could be you. The hair is a little darker; well, a lot darker. But it could have been you 20 years ago.

Having read most of the books, it shows just how dangerous the job is that game wardens do for them in their lives in terms of not just interaction with wildlife, but humans. So we appreciate what you do.

I wanted to get a bit into this topic and ask some questions for you as well as for Forrest. Last year, the Associated Press reported on grizzly bear attacks, and the one fatal one we had in Wyoming, of an outfitter, and noted that conflicts between grizzly bears and humans in the Yellowstone region have become more common as this species has recovered from near extermination in the early 20th century. Although fatal attacks on humans are still rare, and I heard about it in Cody on the 4th of July, talking to folks, they have the bear spray canisters at the airport. There was a story in USA Today about bear spray not being mandatory, but it is a good idea and a suggestion.

What factors are you seeing that generally account for the upticks in human-predator conflicts?

I am going to ask you, Forrest, the same question.

Mr. HOVINGA. Certainly, Mr. Chairman, over the years, since in the last couple of decades, the grizzly bear population has increased and expanded in Wyoming. From 1990 until as recently as last year, looking at the numbers, grizzly bears have expanded from an area approximately the size of 23,000 kilometers to an area of approximately 68,000 kilometers. So the grizzly bear population continues to expand.

Bear densities in the greater Yellowstone area, in the primary conservation area have expanded out in and now occupy about 97 percent of the demographic monitoring area where grizzly bears are managed. They have continued to expand, as the population expands. They reach a density in those core areas and expand outward.

As they expand outward, outside the DMA, the demographic monitoring area, they tend to expand those populations, expand into areas that are more human dominated landscapes. There is more people, more activity, more roads, more camping. And just generally, those bears are now coming into contact with more people than they ever have.

Consequently, our conflicts that we deal with in Wyoming between people and bears, about one-third of those conflicts now occur outside the DMA. So grizzly bears have expanded into those human dominated landscapes and are now making more contacts

with development and people in areas where those conflicts typically haven't happened before.

Senator BARRASSO. Mr. Galante.

Mr. GALANTE. I think Brad summed it up perfectly, the fact that encroachment is the biggest issue. That is a two-way bridge: human populations are increasing as are the bear populations in Wyoming. Prevention is the best option. Prevention is much better than being reactive. What I mean by that is, if we can put some of these innovative techniques into play ahead of having problems, having encroachment issues, people going into bear habitat and bears going into people habitat, then we will see much more passive interactions between people and animals.

Something Brad and I discussed yesterday was using negative reinforcement in order to do that. What I mean by that is, whether you are using the alarm systems that I noted, or shocking the bears, or whatever the situation is, to give the bears a negative association with human beings as opposed to a positive one when they are raiding trash cans and taking food.

Senator BARRASSO. And to the issue of bear spray, which we advocate in Wyoming, not mandatory but we suggest is a good idea, your agency advocates the use of bear spray as an effective deterrent to aggressive or charging bears. Can you just talk a little bit about some inadequacies of the bear spray, when it works, when it doesn't? How can we improve on that?

Mr. HOVINGA. Certainly, Mr. Chairman. First off, will say that we do love bear spray and promote bear spray as an agency. Our employees carry bear spray in the field. We encourage everybody recreating in areas that could be occupied by grizzly bears to carry bear spray.

The one thing, when we teach bear spray education, is that bear spray is a great tool, most of the time, to deter animals during an attack or close contact situation. But one of the pitfalls we do see with bear spray occasionally, and it's good for people to be aware of, is that in adverse weather conditions, like strong crosswinds or headwinds, bear spray can have its effects limited.

If you have a strong crosswind, it may be more difficult for that bear spray to actually reach the intended target, where normally you can get a good 30 feet worth of bear spray in front of you. That distance may be reduced and the effectiveness of how much spray reaches the animal could be reduced also.

Also, consequently, if you have a headwind, you might imagine, as a spray, with lots of particles blowing back onto the user of the bear spray, the self-contamination issue is certainly something to be aware of with bear spray.

So there have been new technological advances in the law enforcement realm, where there has been new products that deal with—like a pepper gel. So it is a heavier substance, that is less affected by the wind, less affected by heavy rain, and it decreases the potential for self-contamination with spray. That would be a great advancement for us to have with bear spray.

Senator BARRASSO. Thanks.

Senator Braun.

Senator BRAUN. Thank you.

Interesting conversation, because I practiced conservation and managed a lot of land, at least I did before I got here, still can do it as much as I can on the weekends. But I am putting in perspective—Wyoming, I think has maybe close to four times the land mass of Indiana. We have about six times the population or so of Wyoming. Most of our wildlife is concentrated into one-third of the 20 million to 21 million acres we have in Indiana.

To look at, from the Lewis and Clark days, when we had probably grizzlies, a whole panoply of wildlife there, and of those 20 million acres, I think 19 million would have been wooded. Ironically, we probably have more deer living on one-third the terrain now when they were completely gone. I remember the only place you could go deer hunting was on a military base, because of subsistence farming and the land that had been cleared from 19 million acres down to about a million.

So through conservation, good stewardship, we brought that back to 6 million to 7 million acres. Beavers are everywhere. Otters have been reintroduced. Both of which now have had trapping seasons, because they have gotten out of hand. Beavers are almost everywhere. It is a beautiful story.

Believe it or not, mountain lion sightings. Because we have more deer than we had, and it was spread over three times the land area. Now it is like a buffet, where you have crops to boot. So I don't view this as pepper spray and being afraid of it, but I personally think we will have nesting, we will have mountain lions that are reproducing in southern Indiana.

Bobcats, for instance, I don't think we had any on trail cams. Now they are pretty well universally around. In a place like Indiana—where you at least have got expanse in Wyoming, in the West—we are going to run into that conflict. Coyotes have prospered; there are more in Indiana now than probably before. I mentioned the other wildlife that has really done well.

Bobcats, we recently had a hearing associated whether we should introduce a trapping and hunting season. Because most of the people in Indiana that pay for DNR and buy a license, or are wanting to hunt small game, so those kinds of conflicts.

I would like to ask you, because I think there have been actually mountain lions passing through. I believe they are possibly reproducing. In a place like Indiana, where you don't have the expanse, where you are going to run into these conflicts very quickly, do you see where an apex predator like that could actually live side by side? I think it would be a beautiful thing if it could happen. But I know even many of the most fearless hunters would be a little bit careful if they knew you had a full, active breeding population of mountain lions in southern Indiana.

Any of you who want to weigh in on it, I would be interested to hear what you think and how we would manage through it.

Mr. HOVINGA. Certainly, Mr. Chairman, Senator Braun. When you have deer populations like you described, and mountain lions move into the area, when there is a prey base to support that animal, they are certainly likely going to do well. As far as mountain lions go, in Wyoming, we have a lot of mountain lions, we have a lot of deer, we have a lot of prey base for those animals. And they tend to do well.

We don't have a lot of conflicts with those animals, with mountain lions, outside of urban areas. Sometimes in urban areas, when they come in, and they typically come into urban areas looking for prey, which is the deer that reside in urban developments. That is when those conflicts arise. Typically, it takes on the picture of a mountain lion comes in in the middle of the night looking for prey, it finds prey, it suddenly gets light, and people come out from everywhere. And that is when the conflict arises.

So certainly those are manageable situations. I do think—to answer your question, I do think you can have, even in areas with a larger population base and less land, coexistence of mountain lions and deer in those communities.

Senator BRAUN. Are there active hunting seasons on mountain lions and grizzlies in Wyoming and throughout the West?

Mr. HOVINGA. Mountain lions, yes, Senator. Grizzlies, no. Grizzlies are currently federally listed under the Endangered Species Act. And we coordinate our management efforts with the U.S. Fish and Wildlife Service on anything we do grizzly related. It has gone back and forth over the last few years. We had control last year when the hunting guide was killed in Wyoming; we had management authority over grizzly bears at that time. We had a hunting season proposed. However, the judge's decision put that bear back on the Endangered Species List before we had the opportunity.

Senator BRAUN. I think we are going to have a round for some other questions, and I will come back, and we'll finish here. I have a few more. What is the harvest on mountain lions in a State like Wyoming through hunting? Roughly.

Mr. HOVINGA. As far as the number we harvest, I don't have that exact number with me. But it is in the hundreds.

Senator BRAUN. In the hundreds, OK.

Mr. HOVINGA. Yes. And in our particular area, in my region, we will harvest in between 20 and 30 mountain lions in our area.

Senator BRAUN. And the population is sustainable over time with that?

Mr. HOVINGA. Absolutely. The way we manage mountain lions is, we have areas that we leave as, some are source areas, that are designed to continually grow in population and be a source for other areas and manage others for stable populations. We have a little higher harvest in those areas.

Senator BRAUN. Thank you.

Senator BARRASSO. Thank you, Senator Braun.

Senator Carper.

OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. Thanks, Mr. Chairman. I have a statement I want to read, but first, let me just say welcome. We also are in different committees, and in one of my other committees, Homeland Security Committee, we had what we call markup, where we were debating a bunch of nominations and bills. I needed to be two places at one time. Hard to do that. I apologize for missing your statements, but we are glad you are here, and we appreciate your responding to our questions.

Ironically, Mr. Chairman and colleagues, my wife—I think I mentioned this—she is hiking the Appalachian Trail this week with her sister and brother-in-law in western North Carolina. I get a daily report on predators that are attacking them and preying on them. I hope she will come back in one piece next week.

When I originally heard about this hearing, I said, well, I don't know if I have a dog in that fight. As it turns out, I have a wife and sister-in-law and brother-in-law. So this is more germane to me than I first thought.

While we don't have a whole lot of top predators in the First State—Delaware is the First State—we were the First State to ratify the Constitution; that is why we are called the First State. Like a lot of Americans, Delawareans are fascinated by predators. In fact, a couple of years ago, one enterprising Delawarean mounted—if you can believe this—a 110-pound fiberglass shark to his dune buggy in honor of a white shark named Hilton that was tracked off Delaware's coast in 2017. While that dune buggy has driven thousands of miles, Hilton has swum thousands more, I think from South Carolina to about as far north as Nova Scotia.

But as the immense popularity of Shark Week demonstrates, millions of Americans are enthralled with these creatures, and with good reason. Predators such as bears and sharks really do play uniquely significant roles in their ecosystems and ours.

These animals control the entire food chains, indirectly influencing everything from the spread of invasive species to carbon sequestration. They sustain healthy populations of commercially and recreationally important fish and game species, and even help to enhance plant diversity.

Many predators are also important for ecotourism. However, as humans continue to encroach upon wildlife habitat and compete with predators for the same space and the same natural resources, our relationships with these animals can become, in some cases, adversarial.

What is more, human-predator interactions are increasingly common, as more people recreate, like my family this week, in wildlife habitat. More than 300 million people visit our national parks each year, and our coasts are more popular than ever for surfing, for swimming, for boating, and for fishing.

Human-predator interactions can impact predators and humans alike. Humans have a history of culling entire predator populations due to conflicts, which has negative effects on our ecosystem.

Predators can also threaten our recreational opportunities, food, and economic security, and in rare but serious cases, cause human injury or loss of life. My wife was describing how they have these bear bags that the put food and stuff, provisions in, and hoist them up so they are up in the trees so bears can't get them. She had a very funny looking bear bag compared to the other hikers; it was sort of like a made at home kind of deal.

Just last fall, two grizzly bears sadly killed a hunting guide in Wyoming. A short while later, a young man tragically lost his life after an encounter with a great white shark off of Cape Cod. Although such tragic outcomes are exceedingly rare, they do happen. As a result, we should consider how human-predator conflicts may evolve over time.

As the range of some prey species shifts in response to climate change, some species cease to exist entirely. Predators may be forced to move to new areas to follow the prey, or find new sources of food. This begs a couple of questions. One of them is, what can we do to meaningfully address human-predator conflicts. A second question would be, how can we protect predators and preserve the important role they play in the environment, while minimizing harmful human-predator interactions.

I like to say that there are no silver bullets when we are trying to solve a particular issue. There are no silver bullets, a lot of silver BBs. Some of are bigger than others. One approach is the legislation before us today, which will support innovative, non-lethal technologies to study, to monitor, and to manage predators.

Mr. Chairman, I appreciate your commitment to innovation and technology. I am pleased to support you in this legislative effort. With that said, I also want to highlight the importance of engaging citizens productively in addressing these conflicts. We need to make sure that good science and data can be used by wildlife managers and decisionmakers when managing predators. The public, who care most about these animals, must have the opportunity, formally or informally, to collaborate with scientists and managers on solutions.

Finally, Democrats on this Committee have proposed a number of bills to address habitat loss, wildlife conservation, and climate change, all of which affect predators, as we know. Many of these bills are bipartisan and non-controversial. I hope this Committee will work soon to advance some of those legislative solutions as well.

Thanks again, Mr. Chairman, for holding the hearing today. I look forward to working with you to advance this bill. I again apologize for missing the first part of this hearing.

Thank you.

Senator BARRASSO. Would you like to proceed, Senator Carper, with a few questions, since Senator Braun and I have both had a chance to ask some?

Senator CARPER. Yes, I would appreciate that. Thank you.

I have 14 questions. Not really.

[Laughter.]

Senator BARRASSO. They are up to it. They can handle it. They are good.

Senator CARPER. We will divide them up.

The first question, this will be for all three of you, if you would. We already see the impacts of climate change on wildlife, increasing air and water temperatures, and rising sea levels, destroying or altering habitat as we know. Evolving weather and rainfall patterns impact food and water availability.

In response to these changes, wildlife behaviors are also changing. For example, orcas are moving north into the Arctic, and scientists have documented the northward migration of bull shark nurseries. Given these impacts, how do you think climate change affects the increasing frequency of human-predator conflicts in the U.S.?

Mr. Whitney, I am going to ask you to lead off, and I will ask each of you to respond. How do you think climate change affects the increasing frequency of human-predator conflicts in the U.S.?

Mr. WHITNEY. Thank you for the question. Yes, as you noted, climate change and rising ocean temperatures do have an impact on several species, including sharks. Most sharks are ectothermic, which means they are cold blooded. Their body temperature is going to be at whatever level the seawater is that they are swimming in.

Senator CARPER. What was that term?

Mr. WHITNEY. Ectothermic.

Senator CARPER. Thank you. I always say, what did you learn today? One thing.

Mr. WHITNEY. You can say cold blooded, too.

Senator CARPER. We use that term a lot around here.

[Laughter.]

Mr. WHITNEY. So as ocean temperatures rise, the sharks' body temperatures will rise, and their metabolic rate will increase, which means they are more active, they are burning more calories, they need to consume more prey to replace those calories.

What we typically see is sharks changing their distribution to stay within their preferred temperature range. They tend to have a range of a few degrees that they like to stay in. So as the area of that preferred temperature range moves north or in whatever direction, depending on what part of the world you are in, the sharks are likely to move to follow that. The same thing is true, most of their prey are going to cold blooded as well, so their prey will move to follow those temperatures.

So in terms of what that means for shark-human conflict, it potentially means that you have sharks coming into areas more commonly where they haven't been in recent history. So people may be used to swimming off beaches and not seeing many sharks, and now, with the warmer water temperatures, you can have more humans in the water, because the water is warmer, for one thing, and they will stay in longer, but then also more shark species coming into those areas.

Senator CARPER. Great. That was good. Thank you.

Mr. Galante.

Mr. GALANTE. Thank you, Senator Carper. As you see species' ranges shift and increase, I think the biggest key is understanding the ecology, as Dr. Whitney pointed out. Then being adaptive for that. So understanding what species are going to shift into what new ecological niches, where they are going to occur, where they haven't previously, and what preventive methods we can take ahead of there being conflict to ensure that there is no issue with predators coming into that environment.

As you pointed out, there is absolutely no doubt that predators are constantly moving, and they are going to occupy new ecological roles in new environments. If we are ahead of that game, understanding and predicting that, then we can mitigate conflict altogether.

Senator CARPER. All right. Very good, thank you.

Mr. GALANTE. Thank you.

Senator CARPER. And Mr. Hovinga.

Mr. HOVINGA. Thank you, Ranking Member Carper.

Climate change with large carnivores in Wyoming is real similar to what these gentlemen have talked about here with other predators. Certainly, climate change affects not only the vegetation and what happens with the vegetative components of the landscape, but it also affects what happens with prey base on the landscape. So when there are changes in vegetation or changes in prey base, that obviously changes how those large carnivores or predators react to that.

For example, grizzly bears, or bears in general being omnivores, can eat a variety of foods on the landscape. However, the foods that they typically may eat that are at a high elevation, if climate change were to cause an issue with those particular foods to be developed, those bears would typically change location and change food sources that may put them in a position to be in more close contact with humans.

So certainly something for us to be aware of, and to track what the effects of climate change are. That will need to be considered in management of all wildlife species in Wyoming.

Senator CARPER. All right, thank you.

If I could, Mr. Chairman, maybe one more quick point.

This would be for you, Mr. Hovinga.

I take it back; this would be for Dr. Whitney.

Technology is often seen as a cure-all for complex conservation challenges. However, as I mentioned earlier, technology is just one tool in the toolbox. Thinking specifically about addressing human-predator conflicts, are there additional non-technology options we need to add to that toolbox?

Mr. WHITNEY. Yes. Thank you, Senator Carper, for the question. I think there are definitely tools besides technologies that need to be incorporated here. A big one is public education, and outreach just informing the general public about the presence of predators, what they may be doing in the area. I think Mr. Hovinga mentioned that in his testimony on grizzlies.

Just hearing some of the stuff about grizzlies, you look at the contradiction. If someone saw a grizzly bear feeding in Yellowstone, you would stay away from that area. With sharks, we take the places where they are feeding, and we swim through them in board shorts and bikinis. So it is really a matter of learning to recognize the areas where sharks may be feeding, adjusting your behavior appropriately, and then taking the things that we are learning about their behavior and their movements and communicating those to the public, so they can make informed decisions about their use of the ocean.

Senator CARPER. Great, thanks.

Thank you all very, very much.

Senator BARRASSO. Senator Markey.

Senator MARKEY. Thank you, Mr. Chairman, very much.

This issue is very relevant to Massachusetts; Dr. Whitney knows this for sure. Because we have seen the return of the great white sharks to Cape Cod. That might be an encouraging sign of a recovering ecosystem. But it brings new challenges for the coexistence of a healthy marine environment, and our residents, our tourists, and our bustling $7.4 billion blue economy in Massachusetts.

In September of last year—I know Senator Carper referred to this—Arthur Medici was killed by a white shark in Wellfleet, the first shark fatality in Massachusetts since 1936. I would like to take a moment to extend my deepest condolences to Mr. Medici's family.

In the wake of that incident, and an additional shark attack in Truro, Cape Cod national seashore officials and Cape Cod towns are making every effort to ensure that Cape residents and the 4 million visitors that flock to the national seashore each year can safely enjoy our nationally acclaimed beaches. In order to safely coexist with sharks, we must increase our scientific understanding of their movements and behavior near the coast.

Dr. Whitney, thank you for joining us today. Does white shark behavioral and tracking research require sustained, secure research funding over several years?

Mr. WHITNEY. Thank you for the question, Senator Markey. Yes, understanding the behavior and movements of any species, especially a large shark, is going to require sustained research. That is a project that has been ongoing now for about 10 years with the Massachusetts Division of Marine Fisheries, as well as with the Atlantic White Shark Conservancy. It has been a combination of some public funding and also private fundraising that has kept that research going.

Most of our work is funded by Federal grants that normally have a 1-year timeline, or maybe 2 at the most. As you can imagine, it can be very difficult to get answers about the long term movements of species that may live for over 70 years, and their movements cover entire ocean basins. So to just go out and study those over a 12-month grant period will not give you a lot of information.

Senator MARKEY. You testified that in addition to scientific research, public outreach is the most effective way to reduce shark-human conflict. Your shark tagging data is publicly available, and the Atlantic White Shark Conservancy's Sharktivity app combines awareness efforts with citizen science.

Dr. Whitney, in addition to informal interactions by way of apps and Web sites, is more formal and structured communication needed to train Cape communities on shark safety and incident response?

Mr. WHITNEY. I would say absolutely. Any form of educating the community is a positive thing, and more formalized education would be helpful, not just in helping people understand the biology of the animals themselves, but also the best ways to handle—in the event of an attack or a bite on a human, how to actually take the appropriate action to save lives.

Most of these bites on humans are not predatory bites. White sharks are capable of eating seals, which are far more formidable in the water than humans. So the fact that most humans that are bitten by white sharks are released rather quickly and actually make it to the beach is a sign that the sharks are not intentionally trying to feed on humans. But of course, even a tentative bite from a white shark can be deadly.

So the most important thing is to make sure that people who are bitten get the medical attention they need as fast as possible to prevent those fatalities.

Senator MARKEY. Thank you. I couldn't agree more. Cape Cod National Seashore is currently coordinating efforts to educate and inform visitors and residents of shark safety and train first responders.

Historically, Cape Cod Seashore Advisory Commission has provided a structured, defined format for communication and education and citizen input from outer Cape communities that are most at risk of white shark encounters. Unfortunately, the advisory commission's authorization expired on September 26th, 2018, only a few weeks after the fatal shark incident in Wellfleet.

That is why I have introduced legislation to reauthorize this citizen commission through 2029, restoring this critical forum for citizen input, and outreach sorely needed to keep our Cape communities safe. I hope that with the support of my colleagues here in the Environment and Public Works Committee and the Energy and Natural Resources Committee, that we can find a way to reauthorize that legislation.

Do you think that would be an important thing to do, Doctor?

Mr. WHITNEY. I am absolutely in favor of more formal education for Cape communities, absolutely.

Senator MARKEY. Much appreciated.

Thank you, Mr. Chairman.

Senator BARRASSO. Thank you very much.

Before heading back to Senator Braun, I do have some additional questions.

Just wanted to give you an opportunity, Mr. Galante, to talk about a show you are going to be hosting during Shark Week on Extinct or Alive on the Animal Planet about your recent travels. Perhaps you could share a little bit about that.

Mr. GALANTE. Yes, certainly. What I do as far as a career is, I travel around the world, primarily working with predators. I do that on television as an education platform, like Mr. Markey spoke about. This year, during Shark Week, we go looking for what is arguably the rarest shark on earth, the Pondicherry shark, a species not seen since the 1970s.

We travel literally to the ends of the earth in search of it, through the Maldives and into very remote Sri Lanka, where we are faced with numerous predators, leopards and tiger sharks, things both terrestrial and aquatic. Not only is it a great adventure, but we have a fantastic scientific discovery that comes out with the episode. It is both worlds.

Senator BARRASSO. It is an hour show?

Mr. GALANTE. It is.

Senator BARRASSO. It is an hour, so people can tune in if they want to see exactly what you find.

Mr. GALANTE. That is correct. It will be on this Wednesday, yes, this Wednesday at 8 p.m. on Shark Week.

Senator BARRASSO. Thanks.

Senator Braun.

Senator BRAUN. Quick question, and Brad, I think I have to aim this at you again. Bobcats would be the current issue in Indiana, because there has been such great restoration. Our Department of Natural Resources has done an excellent job. Of course, that impacts turkey populations; they are predators of fawns. So it is

starting to disrupt—again, it is not a human-predator interaction as much as most of the people that pay for hunting licenses in Indiana are maybe not interested in feeding the bobcats, so to speak.

So in, again, an area that is as compressed as ours is, do you think we will need a bobcat season, either trapping and/or hunting, eventually, to maintain their populations at a healthy level that doesn't beat back the prey to where it would impact hunters who are more interested in turkey hunting and rabbit hunting and squirrel hunting? Even though they don't mind bobcats around, other than if the prey is gone because there are too many.

What do you think we need to do there eventually?

Mr. HOVINGA. Thank you, Senator Braun. In Wyoming and in the West, bobcat management revolves heavily around those cyclic sorts of components of the prey base for bobcats. Bobcats typically, in Wyoming and the western States, rely on small mammals as prey. Bobcat populations tend to fluctuate with upticks and population declines in those small mammal populations.

We don't see effects from specifically bobcats on animals like mule deer. We may see some in the eastern part of the State with turkey, however, I am just not that familiar with that. We could certainly find that information for you in Wyoming. I am on the far western side of Wyoming, and we don't have any turkeys where we are.

But I suspect they would, they would prey on turkeys, given the opportunity. At some point, you may likely be able to support recreational trapping or hunting of bobcats, based on those populations, and establish and how your prey population relates to the bobcat population. That will just be a time will tell, as bobcats are able to establish, and if your agency can document any effects on those prey base populations.

Senator BRAUN. Coyotes would be the parallel to bobcats. Mountain lions, like I say, I think are just coming into the area. Coyotes almost had, I think, unlimited hunting and trapping and still are growing in number. So it is different in a State that has less geography.

Mr. HOVINGA. Correct, Senator Braun. In Wyoming, we do see some of those impacts from coyote populations. We have made some moves, through management, to address some of the harvest of coyotes in an area that are popular for fawning and calving areas for big game animals, in an effort to try to reduce some of those impacts to the deer population. But coyotes do have an impact on deer populations from time to time, specifically when deer populations are low.

Senator BRAUN. Thank you.

Senator BARRASSO. Senator Cardin.

Senator CARDIN. Thank you, Mr. Chairman. I really appreciate our witnesses, what they do every day. I came in close encounter yesterday with a deer in Baltimore City. Pretty close to downtown Baltimore City. So we recognize we have challenges today, make no mistake about it.

I want to start with habitat first, if I might. One of the ways to deal with this issue is to do a better job in protecting the habitat of wildlife. This Committee has a pretty good record here. The last Congress, we reported out of our Committee three bills that I spon-

sored with Republicans: The National Fish and Wildlife legislation that was filed with Senator Crapo, the National Fish and Wildlife Foundation reauthorization that was with Senator Cassidy. That, by the way, is where the Genius Prizes are handled. And the U.S. Fish and Wildlife Service Compensation Act, so that damages that are caused, they can recover the funds, recover for the damages, put it into the trust funds and use it to protect and repair the habitat that has been damaged. That is with Senator Gardner.

I mention that because all three of those bills have been reported out by this Committee, but were held up last year because we couldn't find a vehicle to get it to the finish line. So they pulled out of the LANDS Bill. I would urge the leadership of this Committee to find ways that we can get those bills moving. I do think habitat protection is an area that we can all work on that can have a major impact on dealing with the confrontation between wildlife and humans.

I want to deal with also the realities of climate, which is affecting the realities that the growth of population, the changing in weather patterns have all brought about more conflict between humans and wildlife. I just think this needs to be on our radar screen as we deal with mitigation issues on this conflict.

It is interesting, when you look at the greatest threats, it is insects. We have programs to deal with it. But if you are looking at what is the greatest risk to life, it is insects. And we need to deal with that. Climate change is affecting the vulnerability in regard to insects and human health.

So I hope as we go through this that we look at a comprehensive way to deal with this very important issue. I agree with the Chairman; this is a very important issue, and we need to act on it. But I would urge us to act on it in a way that is mindful of habitat, mindful of the realities of population growth, mindful of the changes in weather patterns, and that we look at a way that takes all that into consideration. And where the greatest risks are to human life and human safety, and not necessarily the ones that make the headlines in our paper, because of the very rare encounter between a bear and a human, which happens too often, or a shark and a human, which happens too often. But it is a rare episode, as compared to some of the others. I don't know how many people have lost their cars or their lives to deer. My guess is it is quite substantial.

So if anyone wants to comment on that, fine. I just wanted to make those observations. I would be glad to hear from any one of you in an extra 2 minutes of presentation before the Committee.

Mr. GALANTE. You are absolutely right, Senator, and I think a big part of that is, as we have briefly addressed, just encroachment issues, building highways through areas that have high deer populations, and things of that nature. What you end up seeing is these ecosystems are in a state of flux, meaning that they are not stable with regard to their predator-prey base. Once they are stabilized, you will have less encounters such as deer on freeways and things like that.

Then of course, there are preventive methods, like what they are doing in Florida, where they are building wildlife corridors under the freeways and over the freeways, to prevent such encounters.

With regard to insects and climate change and things of that nature, that is a very large topic that would take a long time to figure out any kind of a permanent solution. But the ultimate solution would be conservation. It is understanding the ecosystems and understanding how to keep them within balance, and once they are balanced, how that affects all of the human populace that surrounds them.

Senator CARDIN. Thank you.

Thank you, Mr. Chairman.

Senator BARRASSO. Thank you, and I wanted to thank you again for your leadership on this, Senator Cardin, specifically. I know we had a hearing a week or two ago on our upcoming highway bill. We had the head of the Wyoming Department of Transportation—we talked specifically about these interactions with deer and the damage and the loss of life there. That is why I think as part of our markup next week on the highway bill we actually have some things included in the bill that have to do with that. So you will be happy to see that coming.

I want to just ask a couple of other questions. I know we are in the middle of a vote right now, so people are coming and going.

Mr. Galante, to what extent can predator senses be impacted or targeted by innovators, things like smell, sight, hearing, touch, taste? You commented a little bit on how that would work, things we can do to deter unwanted interactions with humans.

Mr. GALANTE. Yes, hugely. Understanding the ecology of a species and its behavior is the best way to come up with non-lethal deterrents. What I mean by that is, as Dr. Whitney can attest to, sharks have a specialized EMR receptive organ named the Ampullae of Lorenzini. If you target that, by putting out electrical currents, you can create fantastic shark deterrents.

The same thing can be said for terrestrial animals, whether you are talking about a canine with a heightened sense of smell, or you are talking about animals with a heightened sense of hearing or sight. It is targeting these specific species based on what instincts and what they use as predators, which is most key to them, and targeting that specific sensory organ and deterring them that way, which is a fantastic non-lethal way to mitigate human-predator conflict.

Senator BARRASSO. Senator Carper, I think you had a unanimous consent request.

Senator CARPER. I do. Mr. Chairman, I ask unanimous consent to enter into the record written testimony and letters from stakeholders as well as other supplemental materials.

Senator BARRASSO. Without objection.

[The referenced information follows:]

July 29, 2019

The Honorable John Barrasso
Chairman, Committee on Environment and Public Works
United States Senate
410 Dirksen Senate Office Building
Washington, DC 20510

The Honorable Thomas Carper
Ranking Member, Committee on Environment and Public Works
United States Senate
456 Dirksen Senate Office Building
Washington, DC 20510

Dear Chairman Barrasso and Ranking Member Carper:

I very much appreciate the opportunity to provide a written statement offering my thoughts not only about the proposed "Promoting Resourceful and Effective Deterrents Against Threats Or Risks involving Species (PREDATORS) Act" (S. 2194), but also the larger challenges of non-lethal coexistence between grizzly bears and people. Please accept these comments for the official record.

A Bit about Me

I spent much of my 40-year professional career studying mountain lions and grizzly bears with the tacit and even explicit goal of better understanding relations between these large carnivores and people. My involvement in grizzly bear research and management ranged from Kluane National Park in the Yukon, through the Mountain Parks of Canada, to the Greater Yellowstone Ecosystem of the United States. My investigations of mountains lions spanned six different study areas in the Southwest, including two in Utah, one in Nevada, and three in Arizona.

In addition to straight-forward ecological studies, my research has focused on conflict between large carnivores and people, as well as among people over carnivores. Of particular relevance here, my studies of mountain lions focused on factors affecting the outcomes of close encounters with people, as well as human safety in urban-wildland contact zones. My research with grizzly bears included close scrutiny of factors driving conflicts on agricultural landscapes in Montana. More recently, I've served as an advisor for non-profit organizations seeking to develop and promote a coexistence infrastructure. Until my retirement in 2015 I also taught topically relevant classes at Yale and the Massachusetts Institute of Technology that were the catalyst for thinking more comprehensively about human-carnivore coexistence.

Institutions are Far More Important than Technology

As evidenced by the proposed PREDATORS Act, non-lethal prevention and mitigation of conflict with humans is recognized by many as central not only to human safety, but also to long-term conservation of large carnivores. My 40 years of experience have taught me, though, that tactics and technologies for preventing and mitigating conflicts can only be effectively deployed as part of a coexistence infrastructure embedded in well-resourced and otherwise sustainable coexistence institutions. Moreover, any meaningful response to long-standing and emerging domains of conflict requires insight into the full panoply of relevant drivers, both human and natural.

Tactics, methods, and technologies are necessary elements of coexistence between people and carnivores, yet only a small part of effective nonlethal regimes. Without intending to disparage the laudable intentions of the proposed Theodore Roosevelt Genius Prize, drones, TASERs, helicopters, and sundry other technologies have been and will continue to be less important—even far less important—than the other, albeit more challenging, facets of coexistence endeavors.

Moreover, insofar as human-grizzly bear conflicts are concerned I contend that most of the important technologies have been invented, even perfected, and that any increments of gain will be well out on the curve of diminishing returns. Numerous really smart creative people have already provided us with highly effective bear-proof or resistant electric fencing, garbage containers, food storage, transfer stations, plus proven carcass composting, deterrent sprays, guard-dog breeds, and husbandry practices.

With that seminal point in mind, I hope in what follows to clarify what I see as the main domains, drivers, and challenges of grizzly bear-human conflict.

Conflicts Occur in Different Arenas with Different Authorities

All but a trivial number of human-grizzly bear conflicts can be assigned to six domains typified by shared drivers and common solutions:

(**1**) Attractants such as garbage and small domestic animals associated with private residences;
(**2**) Collisions with vehicles and trains travelling along heavily-trafficked transportation corridors;
(**3**) Attractants and depredations on private agricultural lands;
(**4**) Depredations and scavenging of domestic livestock on public land grazing allotments;
(**5**) Competition and close encounters with big game hunters on public lands; and
(**6**) Displacement and poaching associated with secondary road systems—also on public lands.

An important higher-order distinction can first be made between human activities associated with conflicts that are wholly confined to private lands, where options for government intervention are more limited (as with [1] and [3]); versus human activities located on public lands or entailing common pool

resources, over which government authority is well-established ([4], [5], and [6]); versus activities on both private and public lands, but on rights-of-way over which governments have primacy ([2]).

These distinctions readily differentiate domains where the primary tools to foster coexistence entail persuasion, subsidies, assistance, and other enticements ([1], [3]) from those where governments have authority to mandate, prohibit, or authorize. In other words, the role of government in modifying human behaviors is inescapable when it comes to managing human-carnivore conflicts—even the adoption of technologies. Corporations and non-profit organizations do not have sufficient authority or even resources.

Most Drivers of Increased Conflict are Directly Related to Humans

The over-arching human drivers of conflict are unambiguous. Leaving aside the all-important role of worldviews and attitudes for the moment:

(**1**) Conflicts over residential attractants are mounting as regional populations steadily increase (e.g., the Flathead Valley in Montana).
(**2**) Likewise, bear deaths from collisions with vehicles and trains have climbed dramatically commensurate with increasing traffic on highways and railways, both as a function of increased intra-regional as well as national through-traffic (e.g., along the Highway 2-Burlington Northern Santa Fe transportation corridor in Montana).
(**3**) Conflicts on public land grazing allotments have skyrocketed, partly because of changes in bears diets and behaviors (see below), but also because government agencies have surrendered their responsibilities for prudent permitting in the face of political pressure generated by well-connected ranchers (e.g., the Upper Green River complex of grazing allotments in Wyoming).
(**4**) Similarly, conflicts over agricultural attractants on private lands have escalated, again in part because of changing bear behaviors (see below), but also because resources and enticements sufficient to deploy proven coexistence techniques have not been available (e.g., the Rocky Mountain Front and eastward in Montana).
(**5**) Conflicts involving sport hunters have steadily increased despite declining and then static hunter numbers, partly because of changing bear diets (see below), but also partly because government bureaus, notably Wyoming's Game & Fish Department, have failed to propagate reasonable and prudent regulations mandating deployment of preventative practices (e.g., requiring that hunters carry deterrent sprays, limiting the time of day when hunting is allowed, and compelling the surrender of hunter-kills when usurped by scavenging bears).
(**6**) Finally, conflicts and bears deaths associated with secondary roads on public lands take a steady toll, and promise to mount as the US Forest Service launches ambitious programs to build and resurrect roads in support of industrial-scale timber harvest (e.g., the Kootenai and Flathead National Forests in Montana).

Importantly, the trends identified in [3], [5], and [6] are closely identified with private individuals gaining profit or pleasure from public resources. As important, with the exception of vehicle and train collisions,

technology will predictably play a minimal, even inconsequential, role in addressing problematic human drivers of conflict between people and grizzly bears.

Environmental Change Rooted in Anthropogenic Causes is Also Driving Conflicts

The other major suite of factors driving grizzly bear-human conflicts pertain to the numbers, distributions, diets, and behaviors of grizzly bears linked, in turn, to past and present environmental conditions. As it turns out, minimal or even non-existent increases in grizzly bear numbers are probably the least important of these drivers.

Minimal Growth of Bear Populations Does Not Explain Increasing Conflicts

Distributions of grizzly bears in the Greater Yellowstone (GYE) and Northern Continental Divide (NCDE) Ecosystems have indisputably undergone major expansions during the last 20-40 years, often into agricultural, industrial, and residential areas where conflicts with humans invariably follow. The question, though, is whether these increases in distribution have been driven wholly or even largely by increasing bear numbers, or by environmental changes that have produced comparative redistributions of high-quality foods towards the peripheries of these two key ecosystems—driving a comparative redistribution of bear populations towards the periphery as well.

In fact, growth of grizzly bear populations has stalled in the GYE and NCDE during the last 5-20 years. There has been essentially no increase in numbers of reproductive females since the early 2000s within the Demographic Monitoring Area (DMA) of the GYE, which encompasses almost all grizzly bears in the ecosystem. Numeric Increases outside the DMA are unknown, but certainly modest and comprised disproportionately of male bears. An almost identical situation exists in the NCDE, although obfuscated by reliance of biologists in this ecosystem on notoriously unreliable methods using data that are, on average, a decade old.

This lack of increase in bear populations begs the question of why grizzly bear are showing up in ever more areas. In fact, the pace at which bear *distributions* have increased in the both the GYE and NCDE has far outstripped even the most inflated claims regarding *numeric* increases of these grizzly bear populations. Rapid increases in population distributions—and related increases in conflict with humans on agricultural lands, in residential developments, and while hunting—cannot be adequately explained by the modest, even nonexistent, growth of grizzly bear populations.

By contrast, much has changed environmentally, most prominently for grizzly bears in the GYE, but also for bears in the NCDE. Although these environmental changes have occurred in the putative natural realm, to call them "natural" is a misnomer given that virtually all have been driven by either anthropogenic climate warming or by invasive non-native species introduced by humans.

Deteriorating Environmental Conditions are Driving Conflicts in the GYE

In the GYE, grizzly bears have suffered catastrophic losses of high-quality foods that previously concentrated them in areas remote from people. Over 70% of mature whitebark pines (a source of fat-rich seeds) was killed in an alarmingly brief 10-year period by an unprecedented outbreak of mountain pine beetles unleashed upon the formally frigid haunts of this tree species by climate warming.

Cutthroat trout, previously available in the center of Yellowstone National Park to bears while spawning in streams tributary to Yellowstone Lake, were functionally extirpated as a bear food by predation from an introduced non-native fish species (Lake trout), but with the effects of this predation exacerbated by deteriorating hydrologic conditions driven by climate change.

Beginning in the mid-1990s, all of the elk herds in core grizzly bear habitat simultaneously declined—some precipitously so—from the combined effects of human sport hunting, grizzly bear predation, wolf predation, and deteriorating summer range conditions, the last also driven by climate warming.

Most of these deleterious changes culminated between 2005 and 2010, shortly before a rapid expansion in distribution of the GYE grizzly bear population and related exponential increases in conflicts with ranchers and big game hunters over meat resources located mostly on public lands. The foci of these conflicts were (and continue to be) livestock on public grazing allotments and publicly-owned elk pursued and killed by sport hunters.

These dramatic increases in meat-related conflicts were unambiguously linked to increased consumption of meat by grizzly bears in compensation for losses of other foods. And, more importantly, all of these dynamics were rooted in anthropogenic causes. None are plausibly explained simply by increases in bear numbers.

Deteriorating Environmental Conditions are Also Driving Conflicts in the NCDE

Similar changes have assaulted grizzly bears in the NCDE. Here, as well, whitebark pine was functionally extirpated, but during an earlier period (1980s-2000) by a non-native fungal pathogen called white pine blister rust. Not by coincidence, the first major expansion eastward of this bear population followed final extirpations of whitebark pine along the Rocky Mountain Front.

On the west side of the ecosystem a sustained drought during 1998-2008 produced a berry famine during which production of fruit on three of the most important berry-producing shrubs was at a nadir. Again, not by coincidence, rapid expansions of the bear population to the west ensued.

Meanwhile, acreages burned by wildfires throughout the NCDE rapidly increased during the same drought period, resulting in a sustained pulse of transient unproductive habitats, the prelude to yet another rapid expansion of grizzly bears to the south and east out from the Rocky Mountain Front. As further inducement for wandering grizzly bears, this period of expansion onto private agricultural lands

coincided with restocking of cattle numbers to record levels after a drought-driven decline, synchronous with a substantial drop in numbers of mule deer, the main alternate source of meat other than livestock for grizzly bears on the High Plains.

Here in the NCDE, as in the GYE, almost all of the deleterious environmental changes plausibly driving expansion of grizzly bears into conflict arenas is ultimately rooted in human causes, including anthropogenic climate warming. Perhaps as much to the point, little of the increased conflict between grizzly bears and humans in the NCDE can be attributed simply to the minimal likely increase in grizzly bear numbers.

Environmental Conditions Will Continue to Deteriorate

Projected environmental trends are not auspicious for grizzly bears. Numbers of people and the associated extent of housing developments and transportation infrastructure will almost certainly steadily increase in the Northern Rockies. Inescapably, conflict arenas will expand and intensify, as will barriers to movement by grizzly bears.

Insofar as foods are concerned, most will likely decline. Climate warming will preclude any chances for recovery or restoration of whitebark pine. Cutthroat trout will also be subject to continued habitat degradation that will prevent meaningful restoration to ecological functionality. The best available science suggests that key berry-producing shrubs will be less abundant throughout the Northern Rockies. Some species are projected to decline catastrophically. Intensified droughts from warming—sufficient to negate any increases in precipitation—will continue to reduce the fecundity of elk. Wildfires will become extensive and frequent enough to overthrow conventional notions that disturbance benefits bears. And army cutworm moths will likely disappear as a food source for bears with disappearance of the alpine flowers that currently sustain over-summering moths.

And what about replacement foods? Most candidates are either unidentified, of lesser quality to the ones likely to be lost, or unlikely to colonize at a pace that compensates for rates of loss. The world will almost certainly become a more difficult place for remaining grizzly bears in the contiguous United States, with predictable intensification of conflicts with humans.

Solutions will Require Honesty, Institutions, Resources, and Reform of State Management

Any meaningful non-lethal response to the daunting challenges of human-grizzly bear coexistence will require honesty about the drivers of conflict. Only then can we collectively develop meaningful and comprehensive strategies focused on priority landscapes. However, effective implementation of such strategies will require substantial human and financial resources, supportive institutions, and changed attitudes among people currently populating state wildlife management agencies.

Unfortunately, willful denial of the dominant and multi-faceted role played by humans in conflicts with grizzly bears is commonplace—including the role of anthropogenic climate warming. The invocation of

phantom increases in grizzly bear populations merely aids and abets this denial, as does a focus on technological rather than cultural and institutional solutions.

One of the biggest obstacles, though, is in the finances, cultures, and practices of state wildlife management agencies, nowhere more so than in Wyoming and Idaho. The default preference among state wildlife managers is unambiguously for lethal solutions to perceived problems. This cultural proclivity is reinforced by financial dependencies upon hunters that create a business model premised on producing harvestable surpluses to satisfy the presumed customer.

This core institutional dynamic will confound any attempt to foster widespread coexistence between people and grizzly bears given that state wildlife managers have an inescapably important role to play. So long as wildlife managers see the solution to human-grizzly bear conflicts as primarily one of killing more bears—whether through sport hunting, lethal resolution of conflicts, or more effectively arming people—gains will be marginal at best in areas of state jurisdiction.

Nowhere is this core problem more evident than in testimony submitted to this committee by Brad Hovinga, representing Wyoming Game & Fish Department, or in a recent decision by his Department's Commission *rejecting* a petition requesting, simply, that hunters licensed by Wyoming be required to carry a proven non-lethal deterrent while hunting in occupied grizzly bear habitat.

Social Acceptance is Little More Than a Political Football

As a perhaps logical derivative of preference for lethal regimes, state wildlife managers such as Mr. Hovinga commonly argue that killing more grizzly bears, whether by trophy hunting or more prompt lethal response to conflicts, will create more "social acceptance" of grizzly bears. However this argument has shaky logical foundations, is at variance with the best available evidence, and is prefaced on a narrow and exclusionary definition of who the public is.

The presumption seems to be that killing grizzly bears, for example through sport hunting, will make those who are currently intolerant of live grizzly bears become more tolerant. Yet the limited research done on this dynamic, notably by Dr. Adrian Treves, suggests that there is no effect, or that the opposite occurs. Intolerance among the intolerant typically remains unchanged, with evidence even of increased poaching as a probable consequence of the tacit permission for such behaviors given by implementation of regimes that prioritize killing carnivores.

Moreover, my personal experience as well as that of coexistence professionals with whom I closely work clearly shows that those who are intolerant will consistently opt for lethal remedy as long as such remedy is readily available and authoritatively sanctioned. Under such circumstances, there is little incentive for such people to undertake the effort or expense of deploying non-lethal preventative measures. More to the point, increasingly permissive lethal regimes will predictably undercut—even negate—the hard work of developing non-lethal regimes founded on widespread adoption of new practices.

Perhaps most problematic, the social acceptance argument fielded by state managers tacitly defines "the public" as being a very small minority defined by a particular geography, ideology, and demographic profile. In other words, those who are currently intolerant of grizzly bears are ideologically predisposed to be intolerant, in a politically favored status, and comprising <1/10th of 1 percent of the American public. By contrast, surveys of the American public writ large consistently show (for example) that around 70% of adults oppose or find morally unacceptable trophy hunting of any animal—including grizzly bears. Similarly, a super-majority of Americans enthusiastically supports recovery of grizzly bears and flock to places such as Yellowstone National Park every year wanting to see live bears.

As a corollary, state wildlife managers as well as certain ranchers and hunters also commonly argue that a small number of local people are burdened with the costs of having grizzly bears, whereas a large number of more distant people reap the benefits. Inequity is the central implied issue. Yet such asymmetries are commonplace with common pool resources. In fact, the local residents who bear most costs are, in the main, heavily subsidized by American tax-payers, including those who graze cattle on public lands for private profit at rates well below market, or those who benefit from hunting for pleasure on public lands maintained at public expense. With such subsidies comes an obligation on the part of beneficiaries to constructively deal with any incurred marginal costs.

In short, there is little or no moral or evidentiary basis for killing more grizzly bears to purportedly build more social acceptance.

People Are Far More Dangerous to Grizzly Bears than Grizzly Bears Are to Us

My concluding thought pertains to human safety during close encounters with grizzly bears, drawing not only on publicly-available data, but also upon my own numerous close run-ins with these bears. First, regarding the data: only 80 people are known to have been killed by grizzly bears in North America going back as far as written records take us—to the mid-1800s. During this same time, people have killed literally 10s of thousands of grizzlies.

Even in the contiguous United States, where grizzly bears still receive Endangered Species Act protections, 80-90% of all the adolescent and adult bears that die do so from human causes, amounting to hundreds of dead bears during the last two decades alone. By comparison, <1/1000th of one percent of all people who venture out of their cars and into the back country occupied by grizzly bears are killed or injured by a grizzly. The asymmetry of risk is profound. We are far more deadly to grizzly bears than they are to us.

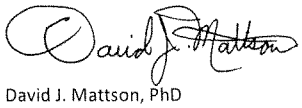
Moreover, having closely scrutinized many of the circumstances under which human injury and death occurred—and been close witness to four—I can confidently assert that most could have been averted by common sense, increased awareness, prudence, better regulations, and better enforcement of regulations. Certainly that holds for the large majority of cases involving hunters.

More concretely, requiring that hunting occur only during morning hours; that carcasses unsecured by nightfall be abandoned; that carcasses approached by a bear likewise be abandoned; that hunting clients be accompanied by a minimum of two guides; plus prohibiting bow hunting in grizzly bear habitat—together would deal with nearly all current risk to hunters. Yet, clearly, to do so would require that state wildlife managers change their stance from that of business-people providing a product to paying customers, to that of stewards of the public trust with an obligation not only to wildlife, but also human safety.

And, finally, insofar as my personal experiences are concerned, including numerous close encounters with—even charges by—grizzly bears, my conclusion is that situational awareness, knowledge of bears, and calmness are the ingredients most critical to a successful outcome. Technology is no substitute, nor, as a friend of mine quipped, is it "brains in a can."

Please contact me if you would like to obtain my resume or scientific literature supporting my testimony. I can be reached at davidjmattson@gmail.com or at 406-222-4702.

Respectfully,



David J. Mattson, PhD

Senator BARRASSO. Mr. Hovinga, since the goal of the Genius Prize we are considering is to protect both predators and humans, regarding predators, the key to protecting their lives involves preventing conflicts with humans in the first place. Can you explain why, from your years and history and knowledge, after a conflict with humans occurs, it may be necessary to euthanize some of these predators?

Mr. HOVINGA. Certainly, Mr. Chairman. That is an unfortunate reality sometimes with wildlife management and wildlife behavior, that we have to realize. With a lot of wildlife, bears specifically and other large carnivores, those behaviors that end up becoming a part of an animal's everyday behavior, that becomes dangerous toward humans, those are learned behaviors. Those are typically learned through successes over time. It usually revolves around those successes in obtaining food.

They tend to learn that behavior over a long period of time. It is perpetuated by success. Just to give you an example of the situation I have dealt with before, this specific one is a black bear, where a black bear learned that if you approach people once in a while, they'll drop their backpack and run away, and you can go over and receive a food reward out of that backpack.

Over time, that particular bear learned to be more aggressive, and the more aggressive that bear was, the higher the probability of that person dropping a backpack and running away. Fortunately, we were able to intervene in that situation, prior to that becoming dangerous and actually somebody becoming injured.

So those learned behaviors are very, very difficult for animals to unlearn. They typically don't unlearn them. It is irresponsible for us as a wildlife management agency to allow animals to remain on the landscape that engage in behavior that is dangerous toward people. Unfortunately, sometimes those animals need to be removed from the population.

So the populations are nearly always doing well enough that those removals are not significant in the scheme of the population management. But certainly, a requirement to keep people safe.

Senator BARRASSO. And a final question, to all three of you, are there technologies currently not available that you envision coming down the line, having the potential to be developed into usable technology to reduce these conflicts? We will start with Dr. Whitney.

Mr. WHITNEY. Thank you for the question, Chairman Barrasso. One of the focuses of my research is utilizing new technologies to learn about shark fine scale behavior. So we use—the tags in front of me here use accelerometers, the same technology that is found in a Fitbit or in your smartphone. So we are not just tracking where the sharks go anymore; we are actually tracking their fine scale movements. We can count how many tailbeats they make during a day or every change in pitch and posture. So we can actually measure activities.

Then we are also starting to use the same technology along with video cameras, so we can get an idea of the context of what is happening, and what other sharks or prey items are around while they are engaging in these behaviors.

So technologies like that are constantly developing and expanding our ability to understand what is happening with the predators. There is also tracking technology now where you can actually follow a shark with an AUV, an underwater unmanned vehicle. You can follow the shark around and occasionally take video clips of what the shark is doing, or record water samples so you know what is happening around the shark.

So things like that are the most exciting in our line of research.

Senator BARRASSO. They do that with submarines, we find the enemy submarines, you follow them around that way, too. Fascinating.

Mr. WHITNEY. Yes.

Senator BARRASSO. Mr. Galante.

Mr. GALANTE. As Dr. Whitney stated, using Fitbits and shark tags, and as Mr. Hovinga stated, using drones, in my opinion, the best use of technology is actually repurposing existing technology, and adapting it to be available for wildlife use, whether that is taking technologies that exist in the tech realm, in the hunting realm, in the fishing realm, in the military realm, and applying that toward wildlife science.

Because what we see is with very small tweaks to existing technology, we are able to apply that tech to our fields, our respective fields of wildlife work. It is much cheaper, more effective and certainly much quicker than trying to develop new technology for these purposes.

Senator BARRASSO. Mr. Hovinga.

Mr. HOVINGA. Thank you, Mr. Chairman. I certainly agree with Mr. Galante, as far as those new technologies, and repurposing. One technology that we have used in the past for aversive conditioning on bears and other habituated wildlife is air horns. But a technology that is out there that would be really helpful is the use of some sort of an acoustic sound technology or sound cannon. Those are directional devices that can project sound a very long distance. You might imagine, using an air horn or something, if you are outside, it doesn't take very much distance for that sound to kind of fade.

But those technologies out there that have been used by law enforcement for crowd control purposes for decades, the military certainly has acoustic sound technologies that they have to use. And some of that technology could certainly be used or modified or made portable enough that it could be used for an aversive conditioning technique for wildlife. Maybe something portable enough that is directional, it could be even a frequency that, instead of just being loud, is something that has a very aversive sort of effect on a bear, and make that technology even more effective.

What if that technology became portable enough that people could carry that, similar to how they do bear spray? Those technologies would be real advantageous.

Senator BARRASSO. I want to thank all of you for being here. This is fascinating. We had a lot of opportunity to ask questions. We thank you for your testimony.

The hearing record is going to be open for 2 weeks, and some of the members who haven't been able to be here and wanted to, but

had conflicts, may actually send written questions. We hope that you quickly will respond to those.

So with that, thank you again for sharing your time and your expertise. The hearing is adjourned.

[Whereupon, at 11:17 a.m., the Committee was adjourned.]