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EXAMINING INNOVATIVE SOLUTIONS TO CONTROL INVASIVE SPECIES AND PROMOTE WILDLIFE CONSERVATION

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

FIRST SESSION

MARCH 15, 2017

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EXAMINING INNOVATIVE SOLUTIONS TO CONTROL INVASIVE SPECIES AND PROMOTE WILDLIFE CONSERVATION

WEDNESDAY, MARCH 15, 2017

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

The committee met, pursuant to notice, at 10:15 a.m. in room 406, Dirksen Senate Office Building, Hon. John Barrasso (chairman of the committee) presiding.

Present: Senators Barrasso, Carper, Inhofe, Capito, Boozman, Wicker, Fischer, Sessions, Moran, Rounds, Ernst, Sullivan, Cardin, Sanders, Whitehouse, Merkley, Gillibrand, Booker, Markey, Duckworth, and Harris.

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

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

Today's hearing will explore innovative solutions to control invasive species and promote wildlife conservation.

Not long ago, Google and Uber were nouns and verbs yet to be discovered, and Amazon was a rain forest in South America. Today we Google to search online, we Uber to move around a city, and we shop online at Amazon. Innovation changes everything.

Since the turn of the twenty-first century, companies like these have rapidly changed our world and transformed every sector of our economy. The wildlife conservation sector is no exception. Federal and State wildlife agencies, wildlife conservation groups, private technology companies, scientists and researchers, farmers and ranchers, hunters and anglers, all are working together to create cutting-edge solutions to our most pressing wildlife conservation challenges.

In Wyoming, we have a profound respect for our wildlife. We applaud the efforts of innovators to help us better conserve and manage our wildlife at lower cost. Wyoming is one of the most beautiful States in the Nation. People travel from around the world to come to Wyoming because our State's natural resources and wildlife are spectacular.

Wyoming doesn't take our exquisite natural resources for granted. When I was in the State Senate in 2005, we established the Wyoming Wildlife and Natural Resource Trust that Governor Freudenthal, who was here testifying just a few weeks ago, signed into law.

Our State wildlife managers grapple with many challenges that innovators can help us solve. For example, poaching is a problem in Wyoming. Hundreds of animals are taken illegally each year in the State, according to our Wyoming Game and Fish Department.

Poaching is a problem in other States too, and it is pandemic overseas. The African elephant population has been reduced by almost 75 percent over the last 10 years, as poachers seek to cash in on the ivory trade. Just this month it was announced that one of Africa's last great tusker elephants, around 50 years old, with each tusk weighing around 112 pounds, was shot and killed by poachers. Over 1,300 African rhinos were poached in 2015 to satisfy demand for rhino horns in countries like China and Vietnam.

Invasive species also present a threat to native wildlife, water resources, and our landscape. Cheatgrass is an invasive species that infests hundreds of millions of acres. Cheatgrass threatens soil retention, burdens already taxed water supplies, provides low quality foliage for wildlife and livestock, and fuels catastrophic wildfires.

Wyoming also faces challenges from other invasive species. The list goes on and on.

Invasive species are a problem for the Country. In Florida, there is the Burmese python, which can grow to more than 23 feet and weigh up to 200 pounds. A few years ago, Senator Nelson brought the skin of a Burmese python to a Committee hearing. It was a striking demonstration. I don't know if you were here that day, but they had the table and then they had to have extensions on the table for the Burmese python to lay out so they could display it. And they grow up to 23 feet. That one that he had that day was less than 23 feet. It was still——

Senator CARPER. Was it alive?

Senator BARRASSO. It was not, no.

[Laughter.]

Senator BARRASSO. We can bring the live one next time.

[Laughter.]

Senator CARPER. A smaller one, maybe.

Senator BARRASSO. The U.S. Geological Survey says this invasive species has devastated up to 99 percent of the area's native deer, racoon, bobcat, and possum populations.

In the Chesapeake Bay area, there is the Northern snakehead, which preys on native fish populations. The Midwest has the emerald ash borer, which continues to kill millions of ash trees across 29 States.

Our Nation's innovators are developing cutting-edge technologies to help us effectively fight poaching, better manage wildlife, and control invasive species. A 2015 National Geographic article outlined a number of innovative technologies being used to promote conservation of many of the world's most endangered species, including a crowd funding to pay for drones to locate poachers, DNA analysis to identify the origin of illicit ivory supplies, deploying thermal imaging placed along perimeters of protected areas to notify authorities of the entry of poachers, and using mobile apps to assist wildlife law enforcement in carrying out their duties.

In December, the National Invasive Species Council cohosted the Summit on Overcoming the Invasive Species Challenge. It publicized innovations to fight invasive species, including a fish pas-

sage that automatically extracts invasive fish from streams, genetic tools to curb the spread of invasive organisms, DNA technologies to provide early detection of invasive species, drones to gain spatially accurate high resolution imagery for the detection and monitoring of specific invasive species.

So I look forward to hearing many innovative ideas conserving wildlife and controlling invasive species from the distinguished panel that we have today. I hope the hearing helps to set the stage for developing bipartisan legislation that will promote new innovative solutions to better battle and manage invasive species, to conserve wildlife, and to limit illegal poaching of rare and valuable species.

I now ask our Ranking Member, Senator Carper, for his comments.

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

Senator CARPER. Thanks, Mr. Chairman. Thanks for bringing us together. And thanks to all of our witnesses for joining us, as well, and for some of you traveling quite a distance. One of you, I think, wears another hat in the Wyoming National Guard. I am an old Navy guy and I said earlier, Navy solutes Army. So thank you, especially for that service, colonel.

I would ask to be submitted for the record a publication article from the National Geographic that was dated, I think, December 31st last year, and it is an article by Jani Actman about some good news, and the good news is something that was followed on about a year after President XI and former President Barack Obama had come to an agreement about a year ago that China would shut down its ivory operations, export and import of ivory. And that is, I think, going to become effective at the end of this year.

I was part of an Aspen Institute seminar in Tanzania about 2 years ago. We had about 20 of our colleagues from all over. Were you there, Roger? There were about 20 of us there. And this was one of the issues that was foremost in our conversations, and I think some good work took place at the very top with the leadership of our two countries, and we are going to see the benefits of that later this year.

But as was apparent from witness testimony during our recent hearing on the Endangered Species Act, the plants and the animals that share this planet with us are having a rough go of it in each of our States and around the world. This is an all-hands-on-deck moment in human history, and while the United States' Endangered Species Act may be a gold standard for species protection and recovery, it is what it has always been, and that is a safety net.

Thanks to a terrific panel of witnesses here today, this hearing gives us a chance to focus on a couple of special challenges that our fish, wildlife, and plants face, as well as to celebrate our creativity in meeting those challenges and to buck up our efforts to find new and better ways to give them a chance to survive.

I very much appreciate, Mr. Chairman, your commitment to stimulate that much-needed creativity.

We will hear today some very worrisome stories about invading sea lamprey and ruthless poachers that will illustrate why it is so important that we are up to this challenge.

These are not minor irritations. These are not inconsequential threats. Wildlife trafficking is a multi-billion dollar enterprise globally, and invasive species cause more than a trillion dollars of harm every year. We have an unassailable obligation to muster the will, the intellect, and the resources to help our challenged fisheries, threatened ecosystems, as well as our treasured bears, our rhinos, and elephants survive in a world that is tough enough.

I want to thank again each of our witnesses for helping us to better understand the fix that our fellow species are in, and for pointing us in a more enlightened direction. I especially want to express my appreciation of the work that each of our witnesses does through their organizations and their teams to fight back. As I said earlier, this is an all-hands-on-deck situation. Your colleagues are all in, and we are grateful for that.

Again, thanks, Mr. Chairman.

Looking forward to hearing your testimony and our conversation.

Senator BARRASSO. Well, thank you, Senator Carper.

I want to remind the witnesses that your full written testimony will be made part of the official hearing record, so I ask that you please try to keep your comments to 5 minutes.

I am going to start by introducing Mr. Brian Nesvik, who has been serving since May 2011 as the Chief Game Warden at the Wyoming Game and Fish Department. He is also a colonel in the Wyoming National Guard. We had an opportunity to be together Thanksgiving 2009 in Kuwait. He was deployed as the commander of the 300th Field Artillery Unit, the Cowboy Cannoneers, running convoy operations into Iraq. He also served as the Regional Wildlife Supervisor at the Wyoming Game and Fish Department in 2010–2011. Before that he was a game warden for over 15 years in Western Wyoming. In 2010 he was the Wyoming Game Warden Association's President. He is also honored by the Safari Club International as Wildlife Officer of the Year.

In many of these positions he has accumulated a wealth of experience in wildlife management, so I hope he will tell us about, based on his extensive experience, things that he has learned in balancing the interests of Wyoming, the citizens, and the abundant wildlife to effectively and efficiently address the challenges posed to the State by wildlife management.

It is a distinct honor to welcome you. I know you have two of your children here today. Thank you so much for joining us at the Environment and Public Works Committee. Thank you for making it through the snow and to Washington yesterday, something, by Wyoming standards, is next to nothing, but it was enough to paralyze the city here.

[Laughter.]

Senator BARRASSO. So, welcome and please proceed.

STATEMENT OF BRIAN NESVIK, CHIEF GAME WARDEN, WYOMING GAME AND FISH DEPARTMENT, CHEYENNE, WYOMING

Mr. NESVIK. Thank you, Mr. Chairman and Ranking Member Carper. Thank you for your gracious and welcoming introduction.

I am hopeful that I can meet your expectations and play my part on this distinguished panel that we have here today to talk about something that in Wyoming is oftentimes front page news. In Wyoming, wildlife is a very important value that many of our folks invest a significant amount of time and energies into.

As you indicated, Mr. Chairman, Wyoming is home to a very rich and diverse wildlife resource, and it is valued by an equally rich and diverse constituency. Much of the State's wildlife habitats remain in the same State they were in the 1800's and continue to provide wide open spaces and remote wild country for western iconic species like the sage grouse, grizzly bear, moose, pronghorn antelope, and elk.

The management, abundance, and quality of these resources are deeply intertwined and work symbiotically with multiple components of the State's economy, including agriculture, tourism, and mineral extraction. But more importantly, these resources directly influence the quality of life of Wyoming citizens and visitors from around the globe. Consequently, I have come to learn that our Nation's citizens deeply believe wildlife in the places they live are worthy of protection from all threats, including invasive species of plants and animals, and the illegal exploitation of wildlife, more commonly referred to as poaching.

I am hopeful Committee members will come to better understand the tremendous potential that exists to improve techniques and tools to more efficiently fulfill our responsibilities to protect, conserve, and manage wildlife under the public trust doctrine and within the tenets of the North American Model of Wildlife Conservation.

Today I will offer my perspective from the view of a State wildlife manager who works very closely with private landowners, State and Federal land managers to achieve our mission. And while I will reflect on my experiences from the State of Wyoming, I will also offer you some thoughts based on my experiences and knowledge with other State wildlife management agencies. I am very fortunate to have the opportunity to be deeply involved with the National Association of Conservation Law Enforcement Chiefs, also known as NACLEC, which affords me a much broader perspective. This network allowed me to reach out very quickly, within 24 hours, and receive feedback from across the entire Country, from many of the States represented by Senators here on the Committee, and this is feedback that informs my testimony here today.

There are three particular areas of wildlife law enforcement and management innovations where I believe the future opportunities exceed those that have occurred in the past.

First, I think you will hear more about this on the panel today because this is such an important capability, and that is the use of unmanned aerial vehicles, or UAVs. They have tremendous potential as tools to protect and manage wildlife in a much more efficient and effective manner. UAVs are capable of carrying onboard cameras, forward-looking infrared, or FLIR, night vision viewers, and other remote sensors. A key benefit to the use of these platforms is the ability to fly them with significantly less power and without placing people onboard.

UAVs, with greater innovation and improvements in their technology, could provide conservation law enforcement officers a much better capability to conduct flights that would otherwise be possible in manned aircraft, but without having to place people in harm's way. With improved capabilities, UAVs could allow conservation officers across the Country to patrol critical winter ranges, waterways where wildlife and valuable wildlife exists more efficiently than could otherwise be done with a motor vehicle, an all-terrain vehicle, motorboats, horseback, or on foot.

Likewise, UAV use has tremendous potential for many of the same reasons in collecting key information on wildlife populations. Some of those uses include aerial classifications of wildlife, monitoring, tracking their movements and migrations, as well as habitat mapping, all of these things that are currently done with the use of manned aircraft at a significantly higher expense.

Second, wildlife forensics. Advancements in wildlife forensics and the analysis of evidence in wildlife cases likely has the broadest potential for impacts with global reach. In a day when the horns from a bighorn sheep poached in the northern Rocky Mountains may find its way to markets in other countries, the value provided by capabilities in wildlife forensics cannot be understated.

Through both chemical and genetic analysis, forensic labs around the Country are able to provide real results that identify the species and source of a particular piece of evidence. Genetics analysis is coming very close to being able to match a particular piece of evidence, like a hair or a horn, to a geographic area of origin.

And, last, looking forward at the FLIR technology that I mentioned earlier, at thermal imaging, they also provide significant potential for new ways to collect information on wildlife populations. You can reference photos and maps, images, in my written testimony and gain some understanding of these tremendous potentials that exist to sample wildlife.

There are other things that I think are important but may not rise quite to the same priority. Those things, such as GPS tracking devices, still cameras to monitor wildlife movements in remote areas, and computer forensics to analyze suspect personal computers in wildlife cases are all important, but this FLIR technology I believe probably has a greater priority.

In conclusion, Mr. Chairman and Ranking Member Carper, there is a need for innovation and development of new techniques in wildlife conservation and protection. While there have been landmark-type enhancements over the past couple of decades that are in use now, there are more opportunities for future development. New technology improves efficiency, reduces costs to the taxpayer, improves the safety of wildlife managers, and provides for more effective conservation.

Opportunities are most likely to evolve and mature with partnerships between private industries, private landowners, governmental entities with a reasonable and practical investment of financial resources in all stages of their development. This has been the model that has been used successfully heretofore, and I believe that it has demonstrated some successes.

Again, I appreciate this opportunity to share my thoughts, and I really look forward to listening to the testimony from other members of this panel and also the dialog with all of you. Thank you.

[The prepared statement of Mr. Nesvik follows:]

Prepared for the U.S. Senate Committee on Environment and Public Works

Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation

Testimony of Brian R. Nesvik
Chief Game Warden/Chief of the Wildlife Division
Wyoming Game and Fish Department

March 15, 2017

Wyoming is home to a rich and diverse wildlife resource that is valued by an equally rich and diverse constituency. Much of the state's wildlife habitats remain in the same state they were in the 1800s and continue to provide wide open spaces and remote wild country for western iconic species like sage grouse, grizzly bears, moose, pronghorn antelope and elk. The management, abundance and quality of these resources are deeply intertwined and work symbiotically with multiple components of the State's economy including agriculture, tourism and mineral extraction. But more importantly, these resources directly influence the quality of life of Wyoming citizens and visitors from around the globe. Consequently, I have come to learn that our nation's citizens deeply believe wildlife and the places they live are worthy of protection from all threats including invasive species of plants and animals and the illegal exploitation of wildlife, more commonly referred to as "poaching". Today I intend to highlight some of the important innovations and technologies currently employed in protecting and managing wildlife along with ideas that have potential for the future. I am hopeful committee members will come to better understand the tremendous potential that exists to improve techniques and tools to more efficiently fulfill our responsibilities to protect, conserve and manage wildlife under the public trust doctrine with the tenants of the North American Model of Wildlife Management as a base.

Today I offer a perspective from the view of a state wildlife manger who works closely with private land owners and state and federal land managers to manage and protect wildlife. While I will reflect on my experiences from the state of Wyoming, I will also offer some thoughts based on my experiences and knowledge of other state wildlife management agencies. I am fortunate to have the opportunity of being deeply involved in the work of the National Association of Conservation Law Enforcement Chiefs (NACLEC) which affords me a broader perspective as I make decisions in the management of Wyoming wildlife resources as well as the things I talk with all of you about today. The network established by NACLEC afforded me the opportunity to very quickly solicit feedback across the country—feedback that informs my testimony today. My testimony today will focus on technologies and innovations for conservation law enforcement and wildlife management. Considering the other witnesses and their fields of expertise, I will only touch briefly on invasive species.

Conservation Law Enforcement Technology and Innovations—Use of Unmanned Aerial Vehicles (UAV), Computer Forensics, Wildlife Forensics, Location Devices, Optics and Cameras

Conservation law enforcement has deep roots in the recent history of our country. As early settlers made their west in the middle and late 1800s market hunting and over-harvest along with habitat loss took many species to near extinction. Species like elk, bison, bighorn sheep, black bears and pronghorn antelope were all but extinct. Those interested in wildlife, primarily hunters and anglers at that time, concluded that the use of wildlife resources must be regulated and that new laws were needed to bring wildlife species back to a state of increased abundance across their native ranges.

The adoption of the North American Model by these visionaries has had lasting influences over conservation law enforcement in the 21st century. Key tenants of the North American Model of Wildlife Conservation like the public trust doctrine, the prohibition on commerce in dead wildlife and the democratic rule of law all persist today as foundations for state led wildlife law enforcement.

New technology has allowed conservation agencies to better protect wildlife and combat poaching. In reviewing the recent past and those practices currently utilized, it is my assessment that while there are tremendous new capabilities provided by the innovations of the past two decades, there are even more opportunities for the development of future technology and innovative techniques to combat the illegal exploitation of wildlife in the future.

Important to note is the fact that with improved equipment and available techniques available to law enforcement officers, there is a corresponding increase in capacity for those who are involved in illegal wildlife activities. Advancements in optics, computer aided navigation and surveillance, global positioning system (GPS) mapping and data sharing as well as communications have all provided new tools for game wardens, outdoor enthusiasts and those who choose to commit wildlife crimes. Additionally, there are new technologies that are of benefit to poachers that have little to no applicability for conservation law enforcement such as long range rifle scopes, automated rifle compensators, lasers, thermal illuminated sighting systems and internet aided remote control killing and trafficking of valuable wildlife. Because new technologies benefit those engaged in nefarious activities, new developments must consider this complexity and the second order affects. These considerations give further rise and justification to the need for additional technologies. Below are several of the most common and useful innovations currently used in conservation law enforcement along with discussions for future opportunities to develop new techniques and improve upon those that are existing.

Unmanned Aerial Vehicles (UAV)

Today there is rapid expansion in UAV technology. While UAVs are currently used in both wildlife law enforcement and management, there is more potential for future application and innovation than what has been developed heretofore. UAVs are capable of carrying on board cameras, forward looking infra-red (FLIR) devices, night vision viewers and other remote sensors. A key benefit to the use of these platforms is the ability to fly them with significantly less power and without placing a person on board. UAVs provide conservation law enforcement officers a capability to conduct flights, that would otherwise be possible in a manned aircraft, without having to place people in harm's way. Over the past 3 decades in Wyoming, there have been more game wardens and biologists seriously injured or killed in plane accidents than in any other single activity including driving. With improved capabilities, UAVs could allow conservation officers across the country to patrol critical ranges and waterways where vulnerable and valuable wildlife exist more efficiently than could otherwise be done in a motor vehicle, all-terrain vehicle, motorboat on horseback or on foot.

Current technology innovation opportunities for UAVs certainly exist and there is more use of these platforms for wildlife management activities (more in next section) than for wildlife law enforcement. However, the new technology required for both has equal suitability and need. Some impediments to their current use include a lack of flying time without recharging the power supply (and consequently their range) and the lack of ability to operate in difficult weather and environmental conditions. While the military partnering with private industry has developed advanced UAVs capable of long flights and the ability to carry heavy payloads, their costs and size make them prohibitive for use in conservation law enforcement. Some examples of potential conservation law enforcement UAV uses include.

- Targeted use on large expanses of public lands where there are vulnerable and previously exploited populations of wildlife. In many parts of Wyoming there are large migrations of mule deer onto winter ranges on lands managed by the BLM. Poachers have taken advantage of large antlered, highly valuable mule deer bucks by killing them during their breeding season near accessible, but remote roads. Based on these problems, the Wyoming Game and Fish Department has conducted task forces in an effort to increase law enforcement presence and more thoroughly investigate crime scenes. While these efforts have helped, one of the biggest challenges in the large expanses of lands and providing enough game wardens to adequately cover all areas simultaneously. The use of UAVs in these areas would significantly improve efficiency and effectiveness of these law enforcement efforts, but require further developed UAVs before their use is possible.
- Crime scene investigations related to the illegally take of wildlife oftentimes span large geographic expanses and can include vehicle tracks in the snow, multiple illegally taken carcasses over large geographic areas, foot tracks and blood trails. Wildlife management agencies use manned aircraft for these purposes now. The use of long range UAVs could significantly increase the ability of wildlife management agencies to gain an overhead view and more thoroughly investigate these crime scenes while evidence is still fresh and more useful.

- There are significant potential benefits to using UAVS to conduct targeted surveillance of suspects or areas where wildlife are being exploited. The ability of UAVs to carry advanced technology cameras, night vision, thermal imaging and FLIR are all enhancements with more future innovative opportunity than current capability. The ability to conduct these types of activities over a long time period in a cost effective manner without the much higher costs of manned aircraft is lacking

Tracking Devices

There is a wide variety of GPS (Global Positioning System) tracking devices for use in wildlife management and conservation law enforcement. The development of these devices is an excellent example of the use of emerging innovation to expand conservation law enforcement effectiveness and efficiency. The newest devices are small, affordable, concealable and can be used to track whole live or dead animals or specific wildlife parts. One example is the SPOT TRACE® GPS tracking device. Once activated, **SPOT TRACE** will acquire its exact location coordinates from the GPS network and send location data to communication satellites that in turn relay this information via the internet to a phone or computer. The device can be tracked by its movement in near real-time via Google Maps. These have been used very successfully by state agencies to quickly detect wildlife violations and apprehend suspects. In a broader context, they have been used to track illegally taken wildlife used in wildlife trafficking across state lines.

Vehicle tracking devices are often used during investigations where a court order has been secured to follow the movements of a specific suspect and target vehicle. These devices allow for remote tracking of a suspect vehicle and associated collection of evidence in real-time and enhance the surveillance efforts of investigators

.

Pit-tags, the same tags used to mark domestic animals, have also been used to successfully identify and track individual wildlife parts. These tags, about the size of a grain of rice, do not allow for real-time tracking but are used to positively identify a specific wildlife part prior to and after it has been recovered as evidence in a crime.

Wildlife Forensics

Forensic analysis of evidence is crucial in the successful prosecution of wildlife crimes. Wildlife forensic scientists must develop, validate, and apply tools to identify an increasing variety of species in a manner that will withstand judicial scrutiny. Forensic analysis is commonly relied upon to perform species identification, cause of death determination, the identification of pesticides and poisons, and to link individual animals to wildlife crime scenes. Cases range from the taking of protected plant and animal species, to oil spills, animal cruelty, sea food fraud and bio-terrorism, to the analysis of animal hairs and other trace evidence in crimes such as rape and homicide or predator attacks on humans. Forensic analysis clearly presents an excellent example of a band of techniques that have evolved and expanded tremendously, but still have

significant potential for further technological advances. Advancements in DNA analysis are at the forefront of both past successes and future opportunities. The Wyoming Game and Fish Department Forensic Laboratory along with a limited number of other similar labs around the country employ the most modern field forensics gathering equipment and techniques.

Enhancements in forensic science in general don't typically come fast and the conservation world is no different. Most new ideas begin small and become a new cutting edge technique only after multiple rounds of testing, review by the scientific community and publishing in scientific literature. Even following these steps, new techniques still require myriad and rigorous validation processes. There are two primary areas of wildlife forensics with opportunity for innovation and growth and those are forensic chemistry and genetics (DNA).

Chemistry

Some of the most applied forensic technology development relates directly to very scientifically based principles in forensic chemistry. Direct Analysis in Real Time—Time of Flight-Mass Spectrometer (DART) analysis is one of the most important emerging techniques related to wildlife law enforcement. DART has been used in a variety of ways. Essentially, DART allows forensic scientists to conduct analysis of suspected wildlife originated substances and determine the species of origin, even when the DNA has been destroyed. As an example, rhino horns can be melted and molded to make what are known as libation cups. The melting process destroys the DNA, but DART can still determine whether the cup originated from a rhino horn or another source such as a horse or domestic cow. A libation cup can be worth as much as $30,000 to $50,000 on the black market and because of their value, there is illegal marketing of counterfeit products.

- DART has been used in timber trafficking cases to determine legal species of imported wood materials. Current estimates indicate that the US alone accounts for over one billion dollars a year in illegal timber coming into the country.
- DART can determine sea turtle carapace which can be made into such things as guitar picks and hair ornaments.
- DART can determine species identification on Pangolin scales. Pangolin are the most trafficked mammal on the planet and are being killed at an alarming rate.
- DART can determine "hoodia" which is a root protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Hoodia is used for weight loss and is currently very popular in China.
- Essential oils are also very popular right now and are often made from protected species of trees especially the Sandlewood and Rosewood tree. One ounce sells for $40. A recent seizure in Utah was detected using DART.

DNA

While there has been work done on numerous species that are common and easier to study (i.e those not listed by ESA or limited in number) there remains a need to generate genetic markers for those species who haven't been studied in the past. The availability of molecular genetic markers is a basic necessity to increased capacity, as well as finding different avenues of answering important questions with decreased or degraded DNA.

Currently a great deal of study and research is being placed on Next Generation Sequencing (NGS). NGS is a high-throughput approach to DNA sequencing. There are numerous applications for this work, however marker development is one of the most important applications. Other opportunities for NGS are listed below:

- NGS has the capabilities of developing markers for microsatellites and single nucleotide polymorphisms which can be utilized for individual animal matching and geographic source identification.
- A second very important application is developing markers that have the capabilities of utilizing smaller quantities of DNA (trace DNA), such as small blood spots or ivory DNA extractions.
- Development of a regional database for thousands of individuals to increase statistical probabilities and improve utilization in court.
- One of the most important applications of this type of analysis has both forensic and non-forensic capabilities. Aquatic invasive species detection in river, ponds, impoundments, or wet lands has been an important non-forensic capability.
    - eDNA (or environmental DNA) is able to detect an invasive species among a great deal of other organism
    - This is often used for Asian carp or bacteria
- Currently the Smithsonian has a proposal to sequence every species on the planet. If done today, NGS would likely be critical to achieve such a monumental task.

Another new invention that has great potential is a small handheld DNA sequencer called a Minion. The operator can buy a kit, connect to a computer and place a blood spot or small piece of tissue or plant directly into the reagents. If developed as intended, the operator would then be able to view the results directly on the sequencer and know the species of origin of the sample. This would be an amazing tool for law enforcement in the field as well as non-lethal sampling of endangered species and it works for plants and animals. A great deal of validation and standardization is required before this equipment can be utilized in the field.

A third emerging piece of equipment being developed in Ohio is a thermal cycler which has the capabilities of being pre-loaded with a kit for primers for such things as Asian carp. This will

allow for agents in the field to detect invasive species. The instrument is currently being beta tested at a cost of $20K. After validation and standardization, this equipment could be very helpful for law enforcement in finding planted invasive fish.

Cameras

Cameras of various types and configurations are used daily in conservation law enforcement and wildlife management. Advancement in their capabilities has improved wildlife law enforcement deterrence and apprehension. These range from digital cameras used to take still photos of crime scenes to high-definition video cameras used for a variety of applications. Here are several examples used by Wyoming, other states and international wildlife conservation organizations.

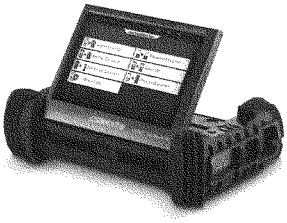
- Trail scouting cameras marketed to hunters and wildlife enthusiasts are widely used by game wardens to expand and enhance coverage of their patrol areas by allowing the game warden to be in more than one place simultaneously. Trail cameras are very effective tools, are relatively inexpensive and are easily replaced if stolen, lost or destroyed. In addition to taking still photos, many of these cameras also have video capability and can be controlled remotely from a smart phone or tablet or can send photos or video to the officer's cell phone or tablet in near real time.
- The Camo-cam® is a stand-alone video surveillance system that can be computer programmed to monitor an area by turning itself on and off and zooming in on a pre-identified target. The camera can be set to trigger from a motion sensor or a seismic sensor set for 2-legged or 4-legged movement.
- There are several different configurations of overt and covert audio/video recording devices used for person-to-person contacts. They include, but are not limited to, pinhole cameras, key fob cameras, ink pen cameras and body wire type devices. All have been effective in documenting conversations related to illegal wildlife activities.
- Pole cameras are real-time monitoring systems that are usually connected to a power pole. The camera can record, zoom in and out and pan in multiple directions. These units are controlled remotely from a computer and are usually used in surveillance of a residence, business or other location where suspected illegal activity is occurring.
- Underwater high definition cameras are being used in the State of Ohio to sample bait fish supplies at shops and aboard transportation trucks for the presence of aquatic invasive species.
- The Wildlife Crime Technology Project is experimenting with thermal imaging cameras integrated with motion detection and recognition software. These cameras are being tested in Africa to identify illegal human entry into protected areas and alert rangers to possible poaching activities.

Thermal/Night Vision Optics

Many wildlife species are active during periods of darkness, searching out food and water or moving between areas of cover. Poaching activities often occur at night by violators using artificial light to locate game. If detected, violators can use the cover of darkness to help avoid apprehension. Advances in thermal and night vision optics, especially in the past two decades, have driven down costs and increased their portability. What were once primarily military technologies are now widely available in binoculars, scopes, cameras and weapon-mounted platforms to the general public at affordable prices. Instead of shining a spotlight that may be seen by a game warden or concerned citizen, violators are increasingly able to use darkness to their advantage while seeking out their quarry using these types of optics. To counter this, many wildlife agencies have equipped their officers with thermal and night vision devices to monitor wildlife and locate suspects during their night patrols. Thermal/night vision devices are also extremely useful during nighttime search and rescue operations and in the lethal removal of invasive terrestrial species (i.e feral hogs).

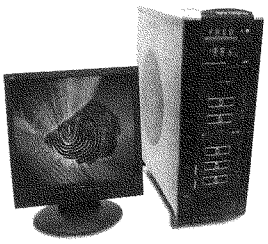
Cellular Phone and Computer Forensics

Electronic evidence has increasingly become a key component in the successful prosecution of those who commit wildlife crimes. Suspects often have text messages, photographs and location information on their cell phones or computers indicating their participation in wildlife crimes. Search warrants are regularly obtained for electronic devices to obtain this evidence. Law enforcement agencies throughout the world utilize specialized equipment for the analysis of computers and mobile devices. As computers, cell phones and electronic devices continue to change with the development of new technology, wildlife law enforcement needs change correspondingly.



The Wyoming Game and Fish Department utilizes the Cellebrite ® mobile forensics system for cell phone and GPS forensic data extractions and analysis. The Cellebrite unit is ruggedized and designed to be used in the field to quickly access the intelligence and evidence contained on a mobile device before it can be deleted or modified, helping to accelerate investigations. The system is updated frequently to keep pace with cellular phone technologies and devices.

Another tool used for analysis of electronic records is the ZetX TRAX program. TRAX automates the mapping process of complex phone records that could be used as evidence into simple, time-lapse, movie-like presentations that investigators and prosecutors can easily understand. A very complicated, time consuming and difficult investigative task is made extremely simple with TRAX.



Wyoming also uses the Forensics Recovery of Evidence Device (FRED) computer forensics system by Digital Intelligence®. This is a stationary system for laboratory acquisition and analysis.

FRED can acquire data directly from all types of hard drives and other electronic data storage devices and save forensic images to Blu-Ray, DVD, CD or hard drives for further analysis or use in a prosecution.

GIS Mapping/Geospatial Analysis

Geographic Information Systems (GIS) are computerized mapping applications with a multitude of uses in wildlife management and law enforcement. GIS data are used to develop high resolution, three-dimensional, interactive maps with various layers of detailed information. Among the many uses of GIS mapping are plotting wildlife locations, delineating habitat types, tracking wildlife violation locations and diagramming crime scenes for use in investigations and prosecutions. Analysis of various GIS data can help wildlife managers and law enforcement personnel identify areas of potential concern and plan future activities.

Smart Phones/Tablets/Computers for Field Game Wardens

Smart phones, tablets and in-vehicle computers are becoming the norm in conservation law enforcement. Smart phones improve officer efficiency and communication abilities, including timely exchange of violation photos and other information. These devices combine the functions of a phone, internet-connected computer, GPS unit, still camera, video camera and audio recorder into one hand held device that is usually with the officer at all times. Equipping officers with these devices in the field allows them easy access to information that was previously only available from an office computer or over the radio from a dispatcher. Countless software applications are available for use in the field to aid officers during investigations. Here are a few examples.

- The Interstate Wildlife Violator Compact Database allows member states to share information on individuals with active or past hunting, fishing or trapping license suspensions. Currently there are 45 member states and three more in the process of joining.
- Most states use electronic systems for hunting and fishing license sales. Through mobile devices, law enforcement officers now have real-time access to these systems to determine if individuals have the proper licenses for the game they are pursuing. Some states, such as South Dakota, have developed mobile apps for their agency personnel that tie together their license database, field check information and law enforcement contact records.
- Software applications for firearm identification can be utilized by officers in the field to narrow down a suspect's firearm based on characteristics from recovered bullets or cartridge casings.

- Case reporting software on a mobile tablet or computer allows an officer to write a case report immediately after a contact with a violator while the incident is still fresh in the officer's mind.

Social Media

Social media outlets have become a critical part of wildlife law enforcement. More and more suspect wildlife violators are using social media in one form or another that provides officers information needed to make cases. Many agencies have developed procedures and processes to preserve social media posts and photographs utilizing computer programs such as "Snagit" ® to capture screenshots. Additionally, there are many ways game wardens and wildlife investigators are using social media to conduct covert investigations as well as identify key pieces of information in wildlife crime investigations that include the sources of resources used to fund illegal commercial activities and the destination of illegally taken wildlife.

Wildlife Management—Use of Forward Looking Infrared, Thermal Imaging, UAV, GPS Collars, Real Time Wildlife Location Data, Wildlife Migration, Cameras

As is the case with conservation law enforcement, new innovation and technology has dramatically improved wildlife management and conservation capability, particularly with regards to monitoring, sampling and collecting valuable information on important wildlife populations. There is significant technological overlap between wildlife management and wildlife law enforcement applications—that is to say, those things that help to locate and collect information on wild animals is also helpful to protect them. This discussion reveals some common threads between different technologies and their application in either collecting raw data on key components of wildlife populations, documenting their migrations and in being able to understand wildlife behavior in real time regardless of their location and the time of the year.

There are as many opportunities for the development of new innovations for wildlife management purposes as there are for any of the other purposes discussed on this panel and in this hearing. Reflecting on the manner in which newly available technologies have been applied in the recent past provide insights into opportunities for the future. Consider the fact that because of GPS technology and huge investments in tracking and monitoring the grizzly bear, we likely understand more about this species than what is known about any other species in the world. Due to real time positioning technology, migration corridors that span over 100 miles have long been known to exist, but only recently have been understood to a scale fine enough to inform point specific management decisions.

More detailed discussion of individual technologies and techniques are included below.

UAVs

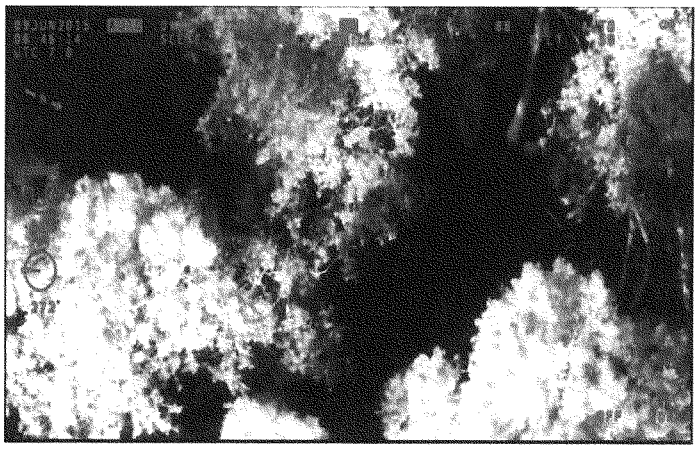
Manned flights allow for collection of valuable natural resource data, however, many of these flights are conducted at low altitudes in difficult terrain. Risks to biologists and game wardens conducting these flights are high and in Wyoming have resulted in more serious injuries and deaths over the past 3 decades than any other individual work activity. As was highlighted in the conservation law enforcement discussion, there is tremendous opportunity to improve efficiency, cut costs and improve personal safety of wildlife managers by using UAVs to do the work that is currently done by manned flight. UAVs are capable of being fitted with various cameras and remote sensing instruments for conducting wildlife surveys, habitat assessments, three dimensional mapping and search and rescue operations.

In one recent example, wildlife managers in Alaska used UAVs to conduct surveys of walrus, whales, musk ox and polar bears. UAVs equipped with forward looking infra-red (FLIR) and thermal imagery were used to map salmon habitat and monitor wildfires. In another example, Idaho State University researchers used UAVs equipped with hyper-spectral imagery over prairie dog towns in northern Montana. The research was conducted in the search for new habitats to trans-locate the endangered black-footed ferret. Lastly, some state wildlife management agencies have experimented with the use of UAVs to more efficiently and cost effectively collect water samples to test for the presence of aquatic invasive species.

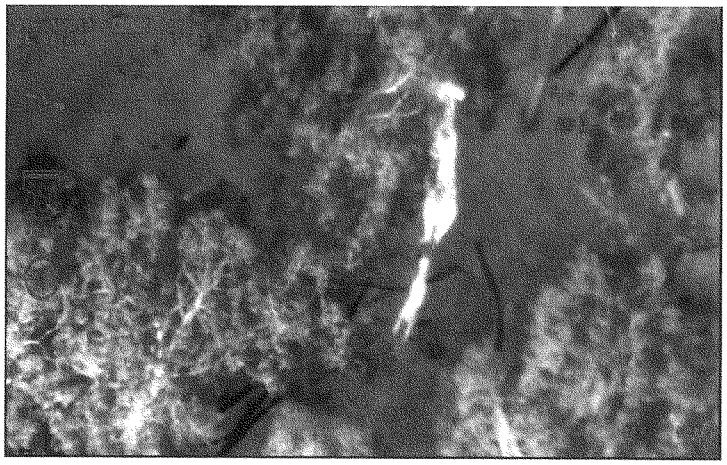
FLIR/Thermal Imagery

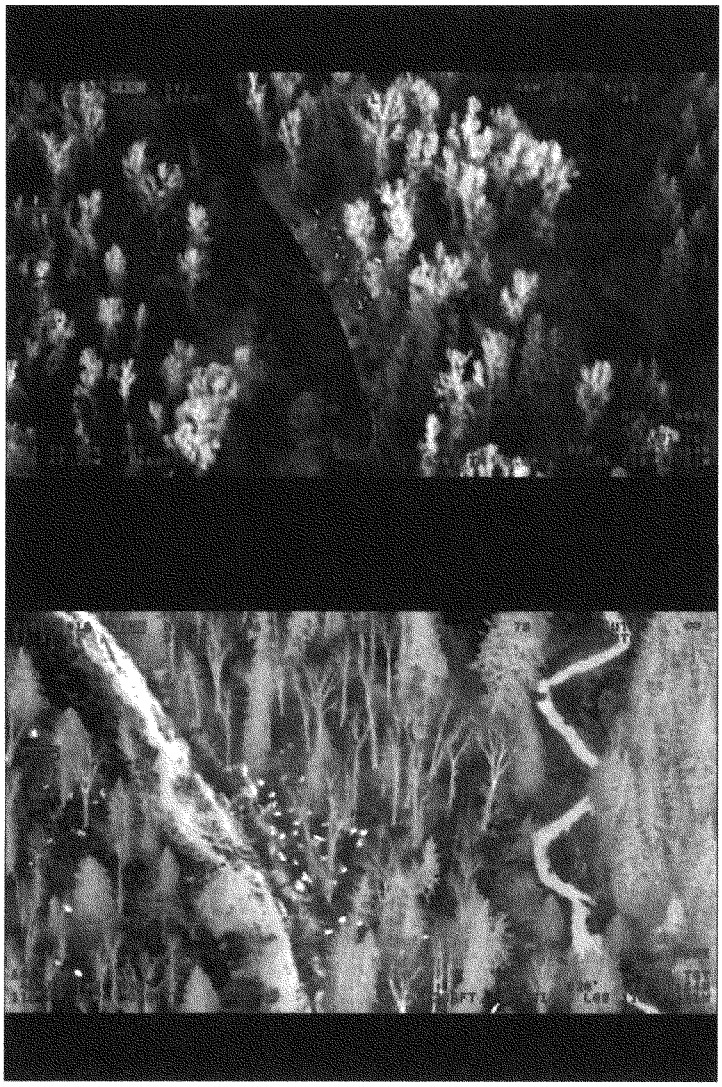
Regardless of the vehicle or platform used to employ FLIR or thermal imagery (manned or unmanned aerial), these technologies have tremendous potential to improve wildlife data collection and monitoring in the future. FLIR uses infra-red light to see through thick tree canopies or in darkness and to a scale that is nearly good enough to identify species. Thermal imagery uses an objects (live or inanimate) heat signature to highlight the shape and activity of the object. Both of these families of devices and function can be mounted on an unmanned or manned vehicle and can be controlled remotely.

The Wyoming Game and Fish Department has used FLIR experimentally to classify elk close to urban areas under heavily treed canopies. They are considering new research that would be specific to pronghorn antelope as a replacement to a decades old population estimation technique and have conducted initial analysis on using this technology to estimate grizzly bear, black bear and mountain lion populations. (see images below)



The top image was taken aerially with normal light and a normal camera. The lower represents a FLIR obtain image of the same location at the same time where you can clearly see the outline of a cow and calf moose





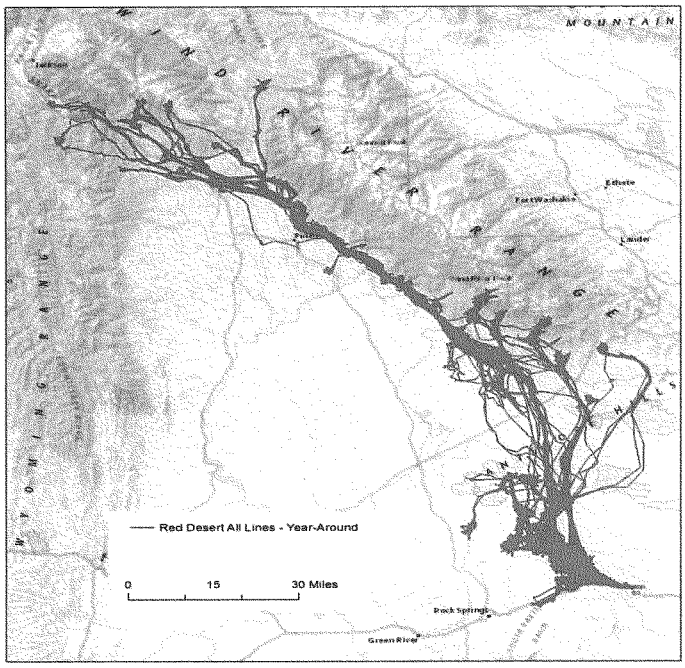
The top image was taken aerially with normal light and a normal camera. The lower represents a FLIR obtain image of the same location at the same time where you can clearly see the signatures of several elk

GPS Tracking

For decades wildlife managers have used VHF frequency radio collars to track and monitor wildlife. This older technology required the capture and fitting of an individual animal with a collar that transmitted a signal for a length of time limited by maximum battery power storage. These collars remained on the animal until the animal either died, the collar belt wore out or the animal rubbed it off. Wildlife managers would routinely fly close to areas where radio collared animals were thought to be located with a radio telemetry tracker. The operator would locate the animal by identifying the frequency emitted by the collar it wore and could then document the time and location. While this technique is still in use, it is being replaced by technology afforded by GPS trackers.

The newest GPS collars have the capacity to last for months and years, fall off at a predetermined date and time and to store thousands of points detailing an individual animal exact location multiple times per day. It is now common for these types of trackers to continuously transmit the location of the animal to GPS satellites so that the animal location can be tracked by biologists in real time. This technology has allowed researchers to exponentially expand their base of knowledge with regards to migration, causes of wildlife mortality, seasonal range use and specific location related behaviors. These innovations may be the most significant with regards to wildlife research in North American wildlife management history.

Elk fitted with a GPS collar caught on trail camera with infra-red flash. Photo courtesy of Joe Riis



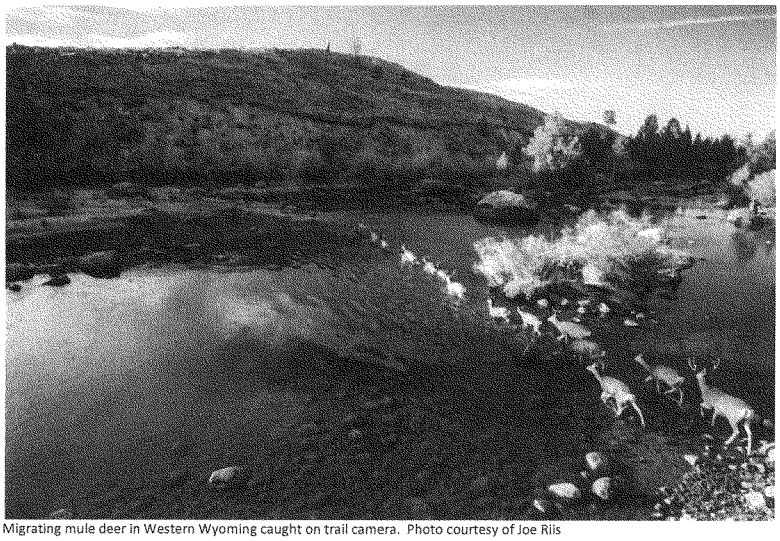
Map with plotted points collected by GPS collared mule deer on a 130 mile migration with elevation gradient spanning from 12,000 feet above sea level to 6000 feet above sea level

Cameras

Camera technology evolution is another significant enhancement that has tremendously benefitted state wildlife management agencies, private land owners, state and federal land management agencies and universities in understanding wildlife biology. With improvements in digital image collection, battery power storage and energy lowering technology, stationary still and video cameras have come to be important tools for wildlife managers. Wildlife managers now build "camera traps" or locations where it is highly likely they will capture images of wildlife in their natural habitats. In some cases, entire herds of migrating ungulates have been classified by age and gender solely by the use of cameras. While it takes manpower to place and recover cameras located in native wildlife habitats, those requirements are significantly lower than those required to conduct flights and foot and horseback ventures into very remote areas to collect the same information. These techniques are new and not widely used yet, however there are significant opportunities for future uses particularly with additional advances in technology.

This still placed camera trap captured these migrating bull elk in the remote backcountry in the Yellowstone Ecosystem

An adult grizzly bear captured with the use of a camera trap and infra-red flash. Photo courtesy of Joe Riis



Migrating mule deer in Western Wyoming caught on trail camera. Photo courtesy of Joe Riis

Migrating mule deer crossing a highway in Western Wyoming. Identification of critical migration corridors have led to the development of overpasses and underpasses to improve public safety, decrease wildlife collissions and maintain the integrity of wildlife migration routes. Photo courtesy of Joe Riis.

Invasive species---use of aerial and satellite mapping for cheatgrass, biological innovations to control cheatgrass, technology and enforcement to prevent AIS from expanding

Cheatgrass

Cheatgrass has become a significant negative influence on native habitats in the west and has become the focus of many habitat management efforts to prevent and control its spread. Below is the background as well as some newer techniques in the experimentation phase to address this potentially landscape altering problem.

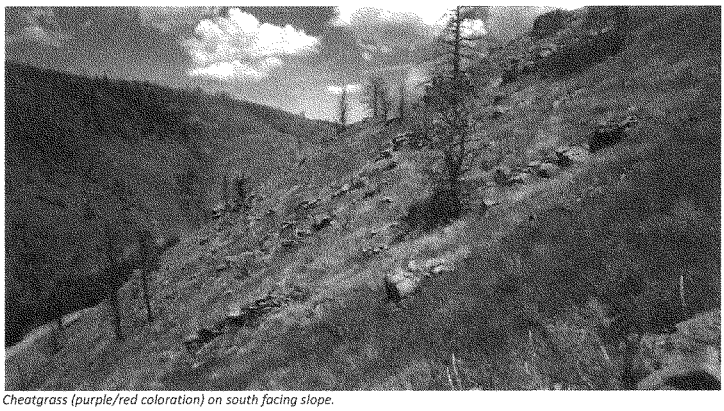
Background

Cheatgrass (*Bromus tectorum*) is an invasive winter annual plant. Germination occurs between fall and early spring and is dependent on timing of precipitation and local climatic conditions. Cheatgrass grows in areas receiving 6"- 22" or more of annual precipitation, and prefers well drained coarse-textured soils. It can be found at almost any elevation, but it does particularly well at elevations ranging from 3,125' – 6,500' in Wyoming. Cheatgrass has recently been documented at elevations higher than 9,000' in Wyoming which has caused a paradigm shift in management as cheatgrass was once thought to only exist below this elevational gradient. South-facing aspects and steep, well-drained slopes provide a perfect environment for cheatgrass to thrive. Its ability to invade into areas, particularly following major disturbances, is unrivaled.

The invasion by this annual has far reaching impacts for management of wildlife habitat, agricultural lands, and the wildland/urban interface. Forage quality and quantity is negatively impacted and wildfire frequency has increased due to a rise in fine fuels caused by cheatgrass presence. An increase in fire frequency favors annual species at the expense of many perennial grasses, forbs, and shrubs which provide important wildlife habitat and forage resources for livestock. The presence of cheatgrass effectively ties the hands of managers, as it can severely restrict the tools used for habitat improvement. The ruggedness of Wyoming's terrain and remoteness of infested sites further complicates detection and treatment options. Managing cheatgrass has proven to be a costly endeavor for state and federal agencies.

New Technology

Remote sensing has proven to be an innovative tool used to detect invasive plants such as cheatgrass and leafy spurge on rangelands. Each species produces a "signature" which is visible remotely from space. This signature can be used to distinguish unique vegetation types on the landscape and is based on properties such as spectral reflectance, transmittance and absorption of plant leaves for ultraviolet, visible, and near infrared frequencies. Cheatgrass populations have been found to be spectrally distinct at three stages in the plants' annual lifecycle: boot stage (formation of grass spikelets), purple to red stage (seedhead maturity) (photo below), and brown stage (senescence).



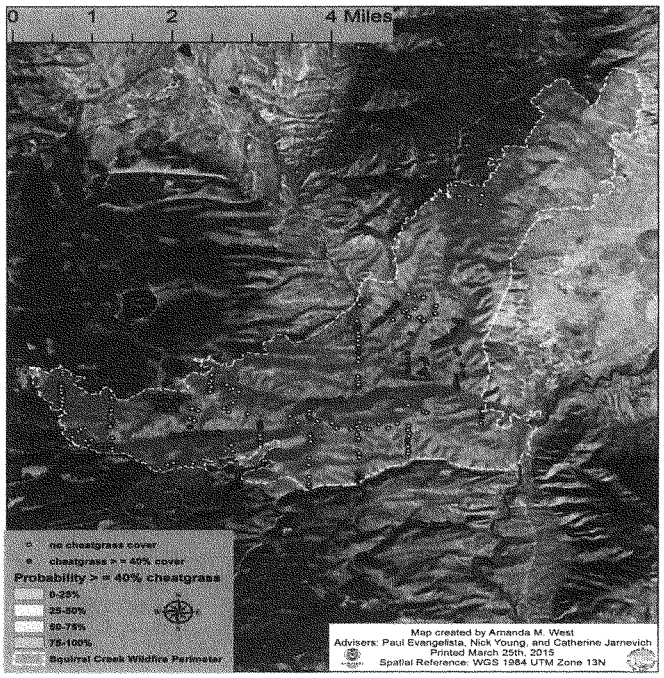
Cheatgrass (purple/red coloration) on south facing slope.

The Landsat 8 satellite was launched in February 2013 by NASA and provides multispectral, moderate spatial resolution imagery of the earth's surface. The satellite provides images with eleven spectral bands. Landsat 8 was developed in a collaborative effort between NASA and the U.S. Geological Survey (USGS). Currently USGS administers routine operations of the satellite and leads post-launch calibration activities, data generation and archiving.

Local Implications

In July of 2012, nearly 11,000 acres of forest and rangeland habitats were burned in the lightning caused Squirrel Creek Wildfire, located on the eastern flanks of the Snowy Range southwest of Laramie, Wyoming. The primary landowner within the burned area is the US Forest Service (USFS). Due to the timing and severity of the fire, cheatgrass was quick to re-invade. The affected habitat is critical for elk, deer, and moose. Personnel from the USFS worked with Colorado State University (CSU), USGS, and the Wyoming Game and Fish Department to utilize remote sensing to map cheatgrass infestations within the burn area. The overarching goal of this endeavor was to validate remote sensing as a viable option in the identification of cheatgrass and formulation of treatment options. Landsat 8 imagery was collected and used over a five month period during the growth cycle of cheatgrass to capture spectrally significant differences.

In addition to imagery, data was also collected in the field by CSU, USFS and Wyoming Game and Fish personnel to ensure that vegetation identified through imagery matched what was on the ground – essentially performing a field calibration of the imagery data. Personnel worked to identify areas of known cheatgrass infestations and determine percent probabilities of cheatgrass throughout the burn area. Through the use of imagery and ground truthing over 3,000 acres were identified as having greater than 50% probability of cheatgrass presence (Image below).

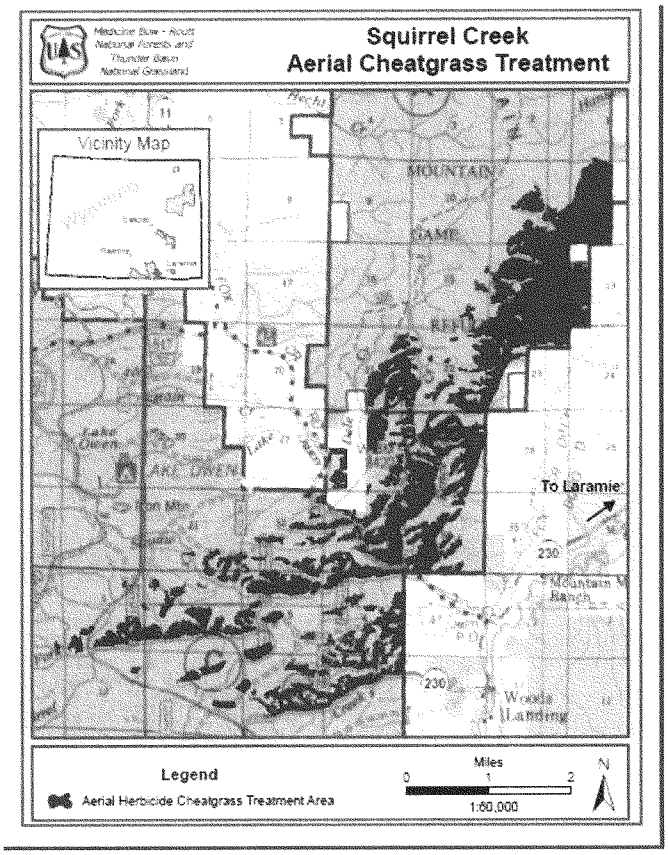


Cheatgrass probability within the Squirrel Creek wildfire burn perimeter.

Other areas within the burn were considered low risk for cheatgrass invasion or had recovered with desired vegetation post-fire. Maps of the infested acres were provided to managers and plans and fundraising was completed to treat these acres in fall 2016. This effort resulted in treatment specific shape files of the affected area. This information was provided to contracted pilots who used the data to strategically spray only the affected acres. Aerial application of the herbicide Imazapic was completed via helicopter in August 2016 on ~3,000 acres of cheatgrass dominated rangelands (See photo below).

Aerial application of herbicide to control cheatgrass within the Squirrel Creek wildfire area.

Through use of cutting edge technology, the Wyoming Game and Fish Department was able to strategically apply herbicide to the acres that needed it the most thereby reducing impacts to non-target plant communities. In addition, the mapping effort resulted in significant cost savings due to the fact that in the absence of remote sensing data we would have likely applied herbicide to additional acres with minimal return and additional costs (map below). The same remote sensing technology will be used to help monitor the treatment area over the next three years. Areas where follow-up treatments may need to occur will be highlighted. The initial acres as well as potential re-treatment acres would likely not be detected by ground based methods due to the ruggedness of the terrain.



Map of acres treated in the Squirrel Creek wildfire area.

Aquatic Invasive Species

State, federal and private wildlife and land management agencies for good reasons have become increasingly concerned about aquatic invasive species over the past decade. For the most part, there are two species of concern those being quagga and zebra mussels. These two species are known to infect bodies of water where they multiply and attach themselves to

boats, but more importantly critical infrastructure like irrigation systems and hydro-electric plants. Below are a few new technologies being used to prevent the spread of these aquatic invasive species

- Mussel sniffing dogs – several states (California, Montana), and Alberta currently use specially trained dogs to detect the presence of juvenile or adult quagga or zebra mussels on watercraft during inspections. These dogs sniff around the boat and alert their handler to the presence of mussels by sitting near the location of the odor. This then lets the human inspector search a specific area of the boat, as opposed to the entire craft. With more specialized training, there is potential that these dogs could even detect the presence of mussel velgers (microscopic larvae) in water on a boat.
- UAVs – Researchers at the Nebraska Cooperative Fish and Wildlife Research Unit have tested the use of unmanned aerial vehicles (UAVs) to collect water samples to then be tested for the presence of zebra/quagga mussels. UAVs use a tube with filter to collect water from varying depths which allows collection of samples without the use of several people and a watercraft. This has the potential to greatly reduce the time needed to collect samples, and has applications for sampling areas with remote access.
- Inspection application – The Western Regional Panel and USFWS funded enhancement of an inspection application originally developed by Colorado Parks and Wildlife, which allows for sharing of data across states and jurisdictions. This app allows an inspector in one location to input public information on a watercraft (such as the registration #), and get data on any previous inspections conducted on that watercraft by other states using the app. This greatly reduces the subjectivity of inspections as they are largely based on boater's response to questions of where a watercraft was last used. This app also allows for quick notification to all western states when a mussel infested boat has left a water, so that the boat can be intercepted and inspected at the destination. States currently using this app include CO, UT, NM, AZ, NV. Wyoming has plans to use this app in the future once we are able to integrate this app into our current data collection system.
- Ballast filter - The Western Regional Panel and USFWS funded development of a filter for wakeboard boats to prevent the intake of zebra/quagga mussel veligers from a waterbody. The filter is over 99% effective when used correctly and properly maintained. This filter can be retro-fitted into existing boats, and efforts continue to have them installed in newly manufactured boats. Draining ballast water from boats continues to be a significant issue during AIS inspections and ballast tank decontamination is time consuming and complicated. This filter has the potential to limit the transfer of mussels in ballast tanks, and to increase the effectiveness of watercraft inspections on ballast boats.

Conclusion and Summary

The citizenry of the United States have a sincere and deep appreciation for wildlife resources and therefore, their protection and conservation. There is a need for innovation and the

development of new technologies in wildlife conservation and protection and while there have been landmark type enhancements over the past couple of decades, there are more opportunities for future development. New technology improves efficiency, reduces costs to the tax payer, improves the safety of wildlife managers and provides for more effective conservation. Opportunities are most likely to evolve and mature with partnerships between private industries and governmental entities with a reasonable and practical investment of financial resources in the initial stages of development. This model has been used successfully heretofore.

Senate Environment and Public Works Committee
Hearing entitled, "Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation"
March 15, 2017
Questions and Responses for the Record for and by Mr. Brian Nesvik

Chairman Barrasso:

1. Mr. Nesvik, as you know, hunters and sportsmen are among the most fervent conservationists. Often, large percentages of state wildlife budgets come from the collection of fees on hunting and fishing licenses.

Can you describe what role sportsmen and anglers have in managing wildlife?

Mr. Nesvik response: *Sportsmen and anglers have played a significant role in wildlife management across the United States for over 100 years. In Wyoming, they continue to be the most significant source of funding for wildlife conservation. Sportsmen and anglers also invest time and effort into shaping wildlife management policy, contributing to on the ground conservation through volunteerism, educating youth and advocating for wildlife values.*

The Association of Fish and Wildlife Agencies (AFWA) supports the utilization of the North American Model of Wildlife Conservation. Most states, including my own, are deeply vested in this model and rely upon its values to guide state decisions related to wildlife management. The role and contributions of sportsmen and anglers are at the core of this model.

In Wyoming during the last two years, nearly 60% of all revenues generated by the Wyoming Game and Fish Department came from the direct sale of hunting and fishing licenses. Additionally, another 6% of all revenue is derived from federal reimbursements under the Pittman-Robertson Act. As many know, funds generated by this act come from the sale of sporting equipment and ammunition. These funds are used to manage all wildlife, even those that are not hunted or fished.

2. Mr. Nesvik, given the scale of the invasive species and poaching problems both within the United States and abroad, I think we can all agree that the circumstances necessitate innovation and ingenuity to meet these threats.

What role do you believe X-prize competitions could play to encourage the development of technology to help solve these problems?

Mr. Nesvik response: *Very simply put, governmental entities don't have the capacity to single-handedly develop needed innovations for future tools to address these problems. Leveraging the private sector through X-prize competitions is an approach that maximizes efficiency of effort and stretches public funds much further than could be achieved if governmental entities unilaterally sought to find new technologies. Many of the current methods used to protect and conserve wildlife like un-manned aerial vehicles (UAVs), global positioning system (GPS) tracking devices, forward-looking infra-red (FLIR), forensic lab techniques and aquatic invasive species detection techniques were developed cooperatively between private companies, institutions of higher*

learning and the government. The military has a long history of collaborative approaches with private industry to acquire new equipment and those endeavors have been successful.

3. Mr. Nesvik, as you likely know, quagga and zebra mussel larva were detected last year in the Missouri River Basin, which flows through Wyoming. Other states have been proactive in mitigating the transfer of aquatic invasive species through watercraft inspection stations. In your written testimony, you also referenced Montana's use of mussel sniffing dogs used for detection. With eradication nearly impossible once infested, what other initiatives can western states take to mitigate initial infestations? How can the Federal government facilitate these efforts?

Mr. Nesvik Response: *Every state has an aquatic invasive species program and they are reasonably well coordinated. However, nearly all wish they had more capacity to conduct more inspections for both boats and other conveyances entering their borders. Equally as important as inspection stations, public information and education is believed to be critical in preventing the spread of invasive species. Inspections help reduce the spread of aquatic invasive species, but education has a significant role in reducing the spread. State agencies simply cannot inspect every boat, but providing public education focused on simple steps the public can voluntarily take has promising potential to avoid spreading mussels. Lastly, states can continue to analyze and re-adjust inspection efforts based on ever changing border risk assessments.*

Additional federal based funding would allow states to enhance detection efforts through additional and existing, but improved inspection stations. Additional technologies and equipment (like sniffing dogs) have the potential to improve efficiency and effectiveness at inspection stations. States would be more able to adapt to new risks with additional inspection stations and to increase the overall amount of time stations are manned. Most importantly, the federal government should continue supporting existing programs. Congress provides funding through the U.S. Fish and Wildlife Service to fund state aquatic invasive species management plans. This funding provides additional technicians who are used for border inspection stations. These federal funds also provide federal (U.S. Fish and Wildlife Service) coordination at the regional and national level. These regional and national panels have been very instrumental in increasing consistency between western states in regulatory, statutory and operational aspects of their aquatic invasive species programs.

Senator Booker:

4. Last month, the Journal of Mammalogy published a study titled "Adaptive use of nonlethal strategies for minimizing wolf–sheep conflict in Idaho" (a copy of this paper is included with the QFRs). During this seven-year case study on grazing operations on large, open-range federal lands in Idaho, researchers found that using a variety of nonlethal predator control techniques significantly reduced livestock losses compared to similar areas where lethal predator control was applied. The nonlethal predator control techniques included increasing the presence of guard dogs; hanging flags around the perimeter of a sheep herd (known as fladry); and using a setup of irregular flashing lights to mimic a human carrying a flashlight.

Given the positive results from this Idaho study, which showed nonlethal predator management saved 3.5 times as many sheep at a very low cost per animal, do you support additional research into nonlethal technologies for reducing human-wildlife conflict in the United States?

Mr. Nesvik Response: *Yes, our Department is always interested in research that may further mitigate livestock conflicts and inform adaptive wildlife management techniques.*

5. Does the Wyoming Game & Fish Department use similar types of nonlethal wildlife management to reduce human-wildlife conflict? Can you provide examples of how this is currently practiced in the state of Wyoming?

Mr. Nesvik Response: *The Wyoming Game and Fish Department supports and implements multiple nonlethal predator management techniques specifically to deal with issues related to depredation of livestock from large carnivores. Currently our personnel employ the use of fladry, turbo-fladry (electrified fladry), scare devices such as propane powered "cannons" and lighting devices all with the intent of deterring an animal from depredation behavior. Personnel work directly with producers to secure attractants and livestock with electric fencing. Many sheep producers who are not operating in occupied grizzly bear and wolf habitat employ the use of guard dogs. The Department has worked with local experts on the use of these specially trained dogs to reduce conflicts. One case in point involved night penning of sheep on public grazing allotments with the use of mobile electric fence pens. When deployed correctly, these electrified pens significantly reduced depredation events on domestic sheep by grizzly bears and wolves on a landscape level grazing allotment. In addition to these nonlethal techniques, Game and Fish personnel work directly with producers in order to educate the public on methods to reduce the potential for conflicts with grazing practices, range riding programs, and the use of combined techniques to reduce depredation and lethal removal of large carnivores on the landscape.*

6. In your opinion, would the state be likely to expand implementation of these strategies if further research continues to demonstrate better outcomes than lethal management techniques?

Mr. Nesvik Response: *The State is always exploring the most efficacious ways to reduce conflicts between large carnivores and humans and adapts our management strategies based on the best available technology and scientific evidence to support conflict reduction strategies. The State has coordinated with non-governmental organizations and USDA-APHIS on evaluation of some of these strategies in areas such as the Upper Green River grazing allotment in western Wyoming to scientifically evaluate the applicability of nonlethal techniques to reduce livestock conflicts with carnivores.*

Senator Sullivan:

7. In your testimony, you outline the effective law enforcement capabilities utilized by state wildlife management agencies in Wyoming.

- Can you speak to how your wildlife managers' local experience makes them most effective in their role in conserving wildlife and habitat?

- Would you argue that State wildlife managers are more qualified than their federal counterparts? If so, how?

Mr. Nesvik response: *In short, I would assert that wildlife resources are best managed by state wildlife management agencies for a variety of reasons. Firstly, those folks who live and work closest to wildlife resources and who benefit from the conservation of those resources are most passionate and skilled in managing them. Our forefathers very thoughtfully placed the ownership of wildlife in state hands to be managed in trust for the greater good and for all citizens.*

Secondly, the states have a strong track record of recovering imperiled species. My state has spent over $45 million over the past 35 years to recover grizzly bear populations. This is more than any other single entity. The results of their efforts and those of citizens who live, work and run their businesses in occupied grizzly bear habitat are a fully recovered grizzly bear population—one that had approximately 135 individuals in the population in the mid-1970s and now has 700 by the most conservative estimates. This population has been recovered since at least 2002 (based on federally established recovery criteria) due in large part to efforts by the states of Wyoming, Montana and Idaho.

In another example, the last remaining individuals of the world's most rare mammal, the black-footed ferret, were found on a ranch in Wyoming in the early 1980s. Efforts by the state to initiate a captive breeding program at a state run wildlife research facility have resulted in reintroduction of black-footed ferrets in multiple western states and back to the area where the last remaining population was discovered in the 1980s. The U.S. Fish and Wildlife Service was involved in this effort; however it would not have been possible without the facilities, expertise and passion of the Wyoming Game and Fish Department.

Third, state wildlife management agencies have demonstrated their abilities to address emerging wildlife conservation challenges in a proactive and timely manner. With rising concerns over occupancy and population densities of the Greater Sage Grouse in 11 western states, state wildlife management agencies quickly developed new approaches to conserving this species. All involved conducted new analysis, worked cooperatively with local ranchers, mineral extraction lease holders, federal land managers and a variety of other stakeholders to develop new management plans and strategies to address these concerns. Ultimately, quick action by states and the people who lived closest to this species prevented a listing under the endangered species act.

Senator BARRASSO. Thank you so much for your very thoughtful testimony. Appreciate you being here today.

We will next turn to Mr. Carter Roberts, who is President and CEO of the World Wildlife Fund.

Thank you, Mr. Roberts, for being here today.

STATEMENT OF CARTER ROBERTS, PRESIDENT AND CEO, WORLD WILDLIFE FUND

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

WWF is the world's largest conservation organization. We operate in 100 countries; we have 5 million members worldwide; and we work with the private sector, governments, civil society, and communities around the world.

When you read in the newspaper, as we did last week, that a couple of individuals broke into a zoo outside of Paris, found a white rhino, killed it and sawed off its horn, you know that we do not live in ordinary times.

Chairman Barrasso already stole my thunder on the scale of the poaching epidemic that sweeps the world, but it ranks right up there among the biggest illegal trade activities out there. And the other shoe dropped when the intelligence communities did a research study of the connection between wildlife crime and the illegal trade in arms and human trafficking and drugs, and at this point the trade in wildlife is bound up in all of those other criminal activities. It is conducted by big criminal syndicates, and it is sophisticated and it is growing around the world.

The U.S. has played a leadership role in two areas: conservation and technology. And I am delighted to talk about how the U.S. is leading in those areas around the world.

Rangers around the world face two great challenges. One is they can't see at night, when the poachers are most active.

Mr. Chairman, you are now holding a miniature version of a FLIR camera that enables you to see the thermal image of anybody in the room. There is a larger version of that camera that we have installed in places like the Maasai Mara and in the Kenya Rhino Reserve where you can see poachers a mile away in the dead of night. In parts of the world where local practitioners are turning down technologies as tricks and toys, they love this technology because it has enabled them to amp up their efforts to catch poachers at a time when they have usually evaded detection; and we are now installing these cameras on jeeps, on the top of towers, and places in Africa, and it is making a huge difference.

The other application of FLIR is being mounted on UAVs, and the New York Times yesterday had some great coverage of our recent partnership with Google, a $5 million partnership to use unmanned aerial vehicles with FLIR technology to track poachers, particularly around the rhino poaching crisis in Southern Africa.

At some point, I would encourage all of you to watch the video coverage of that, and we can come back and do a show and tell. Both of that coverage and the coverage using the FLIR camera to capture poachers in the wild, but it is dramatic and it is real and is making a difference.

There is another way that technology is important in our work, and that is through the illegal trade in animals through Internet trade platforms. And with traffic we are now working with eight global tech companies—eBay, Etsy, Microsoft, Gumtree, Pinterest, Yahoo!, and Twitter—in adopting a framework to prevent the illegal trade in wildlife through their sites.

We are using and testing ongoing technologies, and there are a couple of constraints. One is the ability for civil society to fund and scale-up these technologies. That unit costs $2,500 just for—don't drop it—just that unit. The larger ones cost about $15,000. We need the tech community, the private sector to step in and help us scale-up.

And then we also need the U.S. Government to continue to fund the investment in conservation through the ongoing support and funding for wildlife trafficking, including the END Wildlife Trafficking Act and the National Strategy on Combatting Wildlife Tracking, and the ongoing support for biodiversity conservation around the world through agencies through USAID and the Fish and Wildlife Service.

There are other ways the U.S. can help through unconventional partnerships with the Department of Defense in repurposing technologies that have dual use so they can aid in efforts to stop poachers and wildlife traffickers, and to spur innovation through challenges like the USAID wildlife technology challenge, of which we were a part.

What we found with challenges is they work beautifully if you have a challenge to identify the technology, but you have also thought about the back-end, providing the accompaniment and the support to implement that technology in the field on an ongoing basis.

Meeting our goals will require the sustained support and training for rangers, resource managers and communities, individuals like my colleague from Wyoming and his counterparts around the world. We have seen how powerful these solutions can be. We know the United States is well placed as a leader in both innovation and conservation. We are heartened by the Committee's interest in this subject, and I hope you will continue to find ways to lend your support.

Thank you again for the opportunity to be here today.

[The prepared statement of Mr. Roberts follows:]

WRITTEN TESTIMONY OF CARTER ROBERTS
PRESIDENT AND CEO
WORLD WILDLIFE FUND
FOR THE SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
U.S. SENATE
ON
INNOVATION SOLUTIONS TO PROMOTE WILDLIFE CONSERVATION

MARCH 15, 2017

Chairman Barrasso, Ranking Member Carper, and members of the committee, thank you for the opportunity to testify on behalf of World Wildlife Fund (WWF) regarding innovative solutions to promote wildlife conservation. WWF is the largest private conservation organization working internationally to protect wildlife and wildlife habitats. We currently sponsor conservation programs in more than 100 countries with the support of over 1.2 million members in the United States and more than 5 million members worldwide.

INTRODUCTION

We live in a time of rapid technological change, which is transforming our society across almost all facets of life. The United States has long been at the forefront of this transformation. We have brought our considerable technological might to the world since the days of Samuel Morse, Thomas Edison and Alexander Graham Bell, and have continued innovating ever since with the advent of wireless technologies, machine learning, the internet and beyond. This collection of technological opportunism is probably best encapsulated in the concept of the Internet of Things (IoT): the collection of devices and sensors that share data and enable analysis and improved efficiency. Today, smart homes, wearable technology and connected cars are all built on the notion of the IoT, and the United States remains a leader in its application and expansion. One area that is ripe with opportunities for the development of the IoT is another discipline where the US has long been a leader: wildlife conservation. In the past 5-10 years, we have seen some notable progress in better mapping of our environment and advancing our conservation efforts; tools such as smart collars and smart camera traps have introduced new ways for tracking wildlife. Innovative solutions are much needed in our line of work—particularly now when we are in the midst of the greatest wildlife poaching crisis in recent memory—and the US is well-positioned to lead the way.

THE GLOBAL POACHING CRISIS & RESPONSE

Illegal wildlife trafficking, and poaching to supply this illegal trade, is a primary threat to many of our planet's most charismatic and ecologically important species. It also poses significant threats to security, good governance and economic development objectives around the globe. Wildlife trafficking is now a transnational criminal enterprise worth tens of billions of dollars annually, is strongly connected to other transnational organized crimes, such as drug and arms trafficking, and is helping to finance agents of instability and corruption in many developing countries. The threat to the US is very real as well.

The value of the illegal wildlife trade is estimated at $8-10 billion per year,[1] a figure which puts it in the top illicit transnational activities worldwide, along with counterfeiting and the illegal trades in drugs, people and weapons. In terms of size, wildlife trade outranks the small arms trade. It also has strong connections to other illegal activities—guns, drugs and ivory may be smuggled by the same criminal networks and using the same techniques and smuggling routes. If the illegal trades in timber and fish are included, then the total estimated value of illegal wildlife trafficking rises substantially: the value of illegal, unreported and unregulated (IUU) fisheries alone has been estimated at between $10-23 billion per year, while the value of the illegal international timber trade has been estimated at $7 billion annually.

At the root of the wildlife trafficking and poaching crisis is the growing demand, primarily in Asia, for high-end products made from wildlife parts, such as elephant ivory, rhino horn and tiger skins and bones. Products made from these and other increasingly rare species command high prices on Asian black markets as purported medicinal cures and tonics (e.g. rhino horn powder and tiger bone wine), culinary delicacies (e.g. shark fins) or demonstrations of wealth and status (e.g. ivory carvings). Growing wealth in countries such as China and Vietnam has resulted in a steep increase in Asian consumers with the means to purchase such products. However, the criminal networks feeding Asia's growing demand are global in nature, reaching across oceans and continents and operating in many countries—including the U.S. Middlemen often direct poaching activities and engage in targeted efforts to corrupt law enforcement, border inspection and wildlife protection efforts. In some cases, organized Asian criminal syndicates, which are now increasingly active in Africa, work with local economic and political elites to subvert control systems and operate with relative impunity. It is on the ground, primarily in developing countries and rural regions, where large-scale illegal trade in wildlife and wildlife products has its most devastating effects on local communities, undermining regional security and economic growth while exacerbating corruption and instability. Many developing countries are witnessing the rapid decimation of their wildlife, a potentially valuable resource on which to build sustainable growth and bring greater stability to impoverished and often conflict-torn regions. Wildlife crime is taking a profound toll on ecological systems while also robbing some of the poorest communities of their natural wealth.

But this unprecedented crisis has also provoked an unprecedented global response, with the public and private sectors coming together with civil society to tackle this challenge and working to protect wildlife populations and end the global poaching crisis. The US government has been a major leader in this respect, through Administrative actions such as the creation of the National Strategy to Combat Wildlife Trafficking in 2013, including a whole-of-government task force co-chaired by the Departments of State, Interior and Justice, as well as through Congressional actions such as the passage last year of the END Wildlife Trafficking Act and strong funding support for US government programs that support these official policies and the agencies implementing them. In recent weeks, the Trump Administration reaffirmed these efforts with the release of an Executive Order on Transnational Organized Crime that explicitly mentioned wildlife trafficking as an area of focus.

Non-governmental organizations, such as WWF, have also stepped up to face the current challenge, focusing our efforts, marshalling new resources and forging new partnerships,

[1] http://transcrime.gfintegrity.org/

including in the private sector. Technological innovation to combat poaching and wildlife trafficking is one of the areas of greatest potential for such private-sector partnerships, and WWF has been a leader in piloting such new approaches.

Thanks to a $5 million donation from Google.org in 2012, WWF has committed to advancing ideas, techniques and opportunities to drive the deployment of technology from boots on-the-ground to data in the cloud, to help stop and deter poaching and trafficking of wildlife. WWF has also led the way in combining technology, partnerships and innovations to build, test and scale ideas that will reduce poaching, disrupt criminal networks and save our wildlife heritage for generations to come. Below we highlight some areas where technology is helping us make progress and how we are working with partners to achieve conservation objectives.

CHALLENGE: STOPPING POACHING

Wildlife crime is the most immediate threat to wild rhinos, elephants and tigers. Africa's elephant population has crashed by an estimated 111,000 in the past decade, primarily due to poaching, according to the IUCN's 2016 African Elephant Status Report, which estimates that there are 415,000 elephants across the 37 range states in Africa—a huge drop since the last full update in 2006. The surge in poaching for ivory that began approximately a decade ago—the worst that Africa has experienced since the 1970s and 1980s—has been the main driver of the decline, while habitat loss poses an increasingly serious, long-term threat to the species. In 2016 alone, 1,054 rhinos were reported killed in South Africa. This is a slight decline from the peak of 1,215 in 2014, but still unacceptably high in a country which has seen the poaching rate increase roughly 9,000 percent since 2007, when only 13 rhinos were illegally killed for their horns. The 2016 figure still represents a loss of approximately six percent of rhinos in South Africa, close to the birth rate, meaning the population is perilously close to a downward tipping point. Criminals kill rhinos for their horns, which they then market to willing buyers as a cure for a variety of ailments from fevers to blood disorders to hangovers, in spite of the fact they have no proven medicinal value. Other major rhino range states in Africa have also reported declines, with 61 rhinos reported killed in Namibia this past year, down from 91 in 2015. South Africa, Namibia, and Zimbabwe are home to nearly 95 percent of all remaining African rhinos, and while South Africa's Kruger National Park, home to the world's largest white rhino population, successfully achieved a decline in the number of poached rhinos last year, Africa overall continues to lose an average of three rhinos a day.

WWF Wildlife Crime Technology Project

WWF recognizes the importance of innovative monitoring and enforcement systems as part of an effective 21st-century response to these conservation challenges. The WWF Wildlife Crime Technology Project, initially made possible by our Google.org grant, is a key component of the WWF-TRAFFIC Wildlife Crime Program and is helping us create an umbrella of technologies that not only protect wildlife, but also provide vital resources to wildlife rangers. With an innovative approach that can be easily adapted around the world, WWF is enhancing ongoing efforts to monitor and safeguard vulnerable species. As a science-based organization, WWF spearheads research, development and the integration of technologies in collaboration with governments, private- and public-sector partners. Our partners include African Parks, Cisco, Cornell Lab of Ornithology's Bioacoustics Research Program, Falcon Unmanned, FLIR Systems Inc., Fluidmesh Inc., Google, Kenya Wildlife Service, Mara Conservancy, Namibia's Ministry of

Environment and Tourism, Ohio State University, UAV and Drone Solutions, Unilux and Wildlife Protection Solutions.

Active in Kenya, Namibia, Nepal, Malawi, Zambia and Zimbabwe, WWF's Wildlife Crime Technology Project provides on-the-ground technology support against wildlife poachers and has successfully field-tested a suite of technologies, including:

- Unmanned Aerial Vehicles (UAVs) for rapid response
- Digital monitoring systems that monitor high-risk areas and boundaries of protected areas
- Affordable wildlife/patrol tracking devices connected through mesh networks
- Acoustic detection software
- Micro-radar for monitoring and detection
- Thermal cameras and human detection software
- Data integration and analysis through Spatial Monitoring and Reporting Tool (SMART)

KEY PROBLEMS AND SOLUTIONS

There are two over-arching technology limitations to stopping the poaching of elephants, rhinos and other wildlife across Africa and Asia: the inability of rangers to see at night, when most poaching happens; and the lack of wireless connectivity across the vast, remote landscapes in which the poaching occurs, which impedes the ability of rangers to communicate.

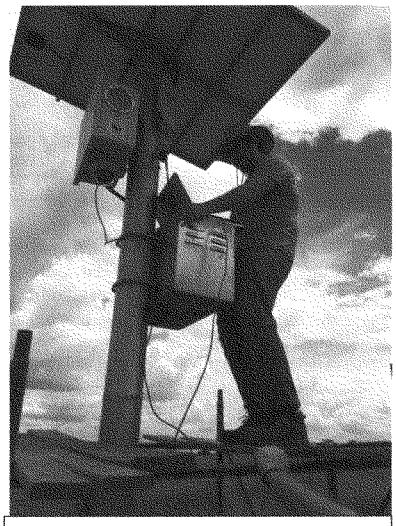


Fig. 1. Installing FLIR cameras with solar panels, Avigilon software, batteries, and radios to send the data to an operations center in Kenya.

Seeing At Night

To help solve the challenge of stopping poaching at night, WWF explored a wide variety of technologies that would help rangers feel confident and safe at night. The technology we felt offered the best opportunity was the use of cameras and video cameras that detect heat. People and animals can be detected in a pitch-black environment based on their heat signatures against the much cooler air and ambient environment around them. WWF began using thermal cameras made by the infrared optics company FLIR. After a year of testing in the United States, in March 2016 we piloted both a static and mobile FLIR set up in Kenya. Working with the Kenya Wildlife Service, we deployed several static FLIR cameras to guard the perimeter of a national park that was the focus of past poaching events, helping rangers scan a part of the park's boundary for illegal human intrusion around the clock. These cameras were equipped with Avigilon software, which allowed them to detect human movement across their field of view on the parks boundary and send alerts to rangers in real-time. This will allow for scaling—without burdening KWS personnel—so that a single person could oversee many additional cameras with no additional time cost.

Nearly eight miles of the park's boundary are now under the watchful eye of cameras. Units are powered entirely by tower-mounted solar panels which, in the arid Kenyan climate, are unlikely to ever dwindle in reserves (Fig. 1). Within the first week, the camera system helped KWS authorities apprehend a potential poacher (Fig. 2). Over the course of the past year, three more intrusions were detected and potential poaching thwarted. Unfortunately, two park rhinos were poached in December 2016 when the poachers gained entrance through another section of the park that lacked surveillance cameras.

Fig. 2. FLIR thermal video camera system, with Avigilon human detection software in use in Kenya. The red box indicates that the cameras identified the object as a human and an alert was sent to rangers of an intrusion. The fence line to the left represents the perimeter of the park, with the road and right side of the image being inside the park.

In addition to the static cameras installed in the national park, WWF worked with the Mara Conservancy in the Maasai Mara, Kenya to install FLIR video cameras atop a ranger vehicle (Fig. 3). In the Maasai Mara, rangers wait for poachers coming from Tanzania who are mostly on the hunt for bush meat. While not specifically hunting for rhinos and elephants, most poachers would not miss an opportunity to seize a valuable kill. The mobile unit will complement existing anti-poaching operations, including ranger foot patrols and a sniffer dog team. The cameras have visibility and are able to detect humans from nearly one mile away. Using the FLIR cameras, the rangers of the Mara Conservancy have greatly enhanced the effectivness and efficiency of their anti-poaching tactics. They are now able to scan a greater field of view to find and better direct rangers to the poachers.

Further, once an ambush is sprung, the poachers are often unable to hide in the darkness as the FLIR cameras are able to see them hiding in the grass, and direct the rangers to their hiding spot (Fig. 4).

Fig. 3. FLIR thermal video camera mounted on a Mara Conservancy rangers' vehicle. The camera is connected to a video screen and joystick to enable panning of the open Mara landscape in search of poachers.

In the December 2016 Mara Conservancy's annual update of their work they highlight the seriousness of the poaching problem, and the impact that the FLIR cameras have had on their work:

> "A total of 434 people were arrested by our rangers in 2016 – even if we remove the 115 people arrested for illegal logging and charcoal burning we still broke the record, set last year, of 318 arrests. The great majority – over 95% - of the arrests for poaching were made in the Serengeti. The remainder were arrests on the escarpment, a few along the River on the Narok side of the Reserve and one or two as they escaped after eluding arrest on the river. The FLIR thermal imaging camera greatly helped in apprehending poachers at night and this equipment is now indispensable in our ambushes. We also smashed the record for the number of snares collected: 7,781 against our previous record of 5,337."

In September 2016, FLIR made an in-kind donation in equipment to WWF to use to support the efforts of our partners across the globe to stop the poaching of wildlife. FLIR has also offered to

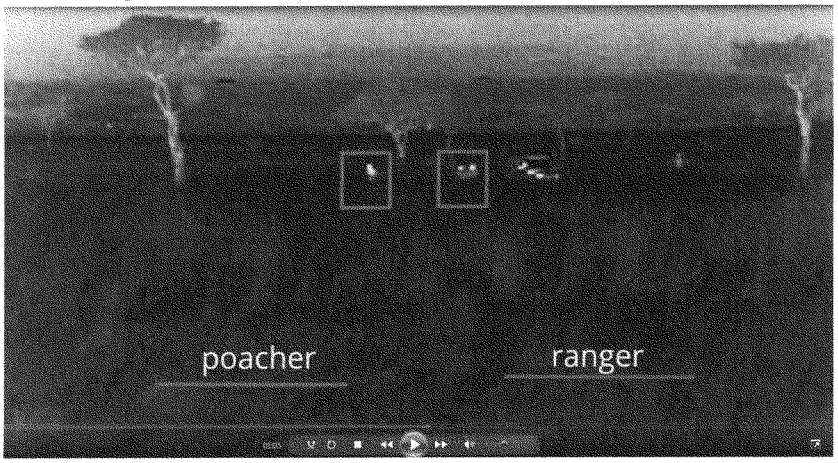


Fig. 4. A still capture from a FLIR thermal camera video showing the apprehension of a poacher in the Maasai Mara, Kenya by Mara Conservancy rangers. The poacher was just flushed from his hiding spot by rangers after the FLIR camera detected the poacher and told the rangers where to find him.

assist with training the new users how to best use and care for their equipment. FLIR's donation is a potential game-changer, giving rangers the capacity to see at night and enhancing their safety by allowing them to avoid poacher ambushes while also steering clear of accidental encounters with buffalos, lions and other potentially dangerous species.

Another use of FLIR has been with Unmanned Aerial Vehicles (UAVs), or drones. WWF has been a leader in testing and evaluating the use of drones for conservation and to detect and deter poaching. Early testing of drones occurred in Namibia in 2013-2014, but was curtailed when Namibia and many other countries banned the use of drones until the laws governing their use could catch up with the technology. In 2015, WWF re-engaged its UAV work to test the technology and determine how best it can assist with anti-poaching. With our partners, we continue to test a variety of drones, as well as FLIR thermal sensors, to gain insight into their capabilities, including finding and identifying poachers. WWF has found that UAVs best function as reactionary eyes in the sky, deployed when an alarm is sounded by another sensor. To that end, WWF is evaluating civilian-grade UAVs for conservation applications with plans to rigorously test the technology in protected areas in southern Africa. For the flight testing, WWF is partnering with UAV and Drone Solutions Ltd (UDS), a licensed UAV operator, and their US-based subsidiary, Cool Ideas Ltd. Our initial work is taking place in Hwange National Park in Zimbabwe and Liwonde National Park in Malawi. We are testing the efficacy of UAV platforms, sensors and protocols for use in conjunction with rangers on the ground and are working to enhance the various sensors that can be used to improve human recognition and data transmission with digital encryption.

Sensors and Connectivity – Improving the ability to move data in real-time
As the costs of Internet of Things sensors become cheaper, we envision a future where a vast array of networked sensors feed data into a central control and management center, within a national park or protected area. WWF is investing in the development of these sensors and partnering with private companies to determine how to move vast amounts of data cost-effectively in real-time. While there are potentially expensive, security-restricted technology solutions developed by research entities in the Department of Defense, military-grade sensors are not required for wildlife conservation purposes. Instead, WWF has focused on leveraging these advancements to design and power lower-cost sensors to assist in detecting intrusions and potential poachers. Other innovation projects currently underway include:

- WWF and Cornell University are working together to gather data on a recently developed gunshot detector which, if successfully rendered, would be a great asset to rangers in the field, allowing alerts to be sent to a ranger control center whenever a gunshot is detected. We envision setting up gunshot detectors in vulnerable but unpatrolled areas where wildlife congregate, such as remote water holes.

- In Nepal, we are piloting a vehicle tracking system for authorized vehicles used by private agencies conducting safari tours. WWF is partnering with the Nepali Army to outfit vehicles with GSM-based tracking devices and develop a custom-built application that can locate and visualize all vehicles in the park. An alert system will ensure all vehicles leave the park within the permitted hours and notify security units if vehicle stop times exceed the allowed limit.

- WWF is exploring the capabilities of radar to detect wire snares, which are set illegally by the tens of thousands throughout wildlife habitat around the world, constituting one of the greatest threats to wildlife. WWF and our partners are exploring Impulse Radar, a relatively simple, low-power circuit that sends short radio pulses from an antenna and listens for echoes from radio pulses bouncing off a target—in this case the wire snare.

Anti-poaching efforts can be thwarted by the poor communications connectivity common in most large protected areas, where perimeter security is also a key challenge. The lack of secure, reliable connectivity between central operations, sensors deployed in key wildlife areas and field rangers inevitably impedes efforts to coordinate and respond to poaching incidents. To address this challenge, WWF and Cisco Systems (Cisco) formed a collaboration in 2016 to drive innovative technology solutions to diminish the threat of poaching and mitigate human-wildlife conflict. Dimension Data (DD), a communications business leader across Africa, is also a partner on the project and has worked with Cisco to pilot technologies for conservation in South Africa where we have been able to reduce the poaching of rhinos by 90% over the last 2 years. WWF, Cisco and Dimension Data plan to invest in and install technology in Africa and Asia to improve two-way communication between operations headquarters and rangers and sensors in the field, using of low power, long range wireless networks (LoRa) and cellular networks to enable wider-scale communication. Such connectivity will allow park management to track vehicles, rangers, and tagged animals, and to connect to unattended sensors such as camera traps, cameras, gunshot detectors, radar detectors, etc.

We will also assess UAVs, night vision thermal scopes and cameras to improve operation and safety of night time ranger anti-poaching patrols.

Ranger Analytics: Data Analysis to Deter Poaching
As the Internet of Things continues to grow in size and productivity, there will be massive amounts of data from sensors that can be analyzed to improve efficiency of anti-poaching management. SMART (Spatial Monitoring and Reporting Tool) is an innovative management tool to assist rangers on the ground in curbing poaching and illegal trade of wildlife. SMART was developed with the recognition that traditional tools, technologies and resources were not effective enough at stemming these problems for a number of reasons. One critical issue is the growing gap between the sophistication of the criminals involved and the number, skill levels and motivation of the ranger force. SMART was designed to help bridge this gap. Its combination of software and training materials provides enforcement authorities and community groups with the ability to empower staff, boost motivation, increase efficiency and promote effective monitoring of anti-poaching efforts. SMART can do this because it is more adaptive and intuitive to use than other monitoring technologies, and because it has more advanced analytical and reporting functions.

SMART is free, open-source data storage and analysis software that incorporates intelligence gathering and patrolling data to aid in strategic planning of enforcement activities. SMART also allows accountability in anti-poaching efforts by offering government agencies, managers and donors the ability to assess the effectiveness of protection efforts and investments. SMART is now used in more than 30 countries and is supported by a partnership that includes the Zoological Society of London, Peace Parks Foundation, Panthera, Global Wildlife Conservation, the North Carolina Zoo, Wildlife Conservation Society, Frankfurt Zoological Society and World Wildlife Fund.

STOPPING WILDLIFE TRAFFICKING
It is estimated that 3,000 kg. of illicit rhino horn reaches Asian markets each year (an average horn weighs 1-3 kg. depending on the species). Evidence indicates that horn smuggled from South Africa will go directly to consumer markets in Asia, to traders in Vietnam, Laos and China. The spike in rhino poaching has surged due largely to rising demand for rhino horn in Vietnam, where some believe it cures cancer and others employ it as an aphrodisiac or hangover cure doubling as a status symbol due to its exorbitant cost. A new trend is demand for carved rhino horns and rhino horn beads to be worn in bracelets. Wealthy buyers have driven up prices and demand for rhino horn to a level where it is now being sourced not just from live rhinos in Africa and Asia, but also from live captive animals, trophies, antiques and museum specimens in the U.S. and Europe. One need only look to the very recent killing by poachers of a white rhino living in a zoo outside Paris as clear evidence of the continued global thirst for animal parts; the criminals hacked off the rhino's horn before escaping.

In terms of ivory trade flows from Africa to Asia, East African Indian Ocean seaports remain the paramount exit point for illegal consignments of ivory today, with Kenya and Tanzania as the two most prominent countries of export in the trade. This development stands in sharp contrast to ivory trade patterns previously seen, whereby large consignments of ivory were also moving out of West and Central Africa seaports.

Poaching is now seriously affecting all parts of Africa where elephants are found, and large bulky shipments are often exported via the shortest routes or paths of least resistance where the large volume of sea containers or air freight helps to make it more challenging to detect, or where corruption easily allows movement of illicit cargo.

China and Thailand are the two primary destinations for illegal ivory consignments from Africa. While repeated seizures of large consignments of ivory have occurred in Malaysia, the Philippines and Vietnam since 2009, these countries essentially play the role of transit countries to China or Thailand. In the case of Vietnam, which shares a long terrestrial border with China, ivory is being smuggled overland into China.

Without any doubt, ivory consumption in China is the primary driver of illegal trade in ivory today, and China remains the key for stopping the growing poaching crisis facing Africa's elephants. The Chinese government recognizes ivory trafficking as the country's greatest wildlife trade problem, and law enforcement officials are making almost two ivory seizures every day, more than any other country in the world. Various observers to China, including TRAFFIC monitors, have found government-accredited ivory trading retail outlets persistently selling ivory products without the benefit of product identification certificates, which are an essential feature in the Chinese control system. This circumvention creates the opportunity to substitute products from illicit sources of ivory into the legal control system. In light of these challenges the Chinese government has announced that it will close the legal trade in ivory domestically by the end of 2017. In the US ivory trade has largely been banned, with some exceptions, but increasingly illegal ivory trade has gone online, often disguised as mammoth ivory or ox bone to avoid detection. The same may happen in China when its domestic trade ban comes into effect.

Rhino DNA Technology Links Crime Scenes to Criminals

Technology has many roles to play in stemming and reducing the trafficking of illegal wildlife products, as well as invasive wildlife species. For example, the Veterinary Genetics Laboratory at the Faculty of Veterinary Science (VGL) of the University of Pretoria, South Africa has been at the forefront of providing genetic profiling of Black (*Diceros bicornis*) and White (*Ceratotherium simum*) rhinos for the South African government since 2010. The DNA system registered as RhoDIS® has established a rhino DNA database for rhino profiles, which allows rhino range states access to share data and information for combating rhino crime.

DNA is a traceability tool. In application, DNA profiles from rhino horn directly match recovered horn to individual rhinos and poached rhinos and can link poachers, traffickers and horn from consumer countries or individually identify stockpiled horns. The advantage of this technique is that DNA cannot be removed, changed or destroyed. DNA profiles provide information unique to each individual, telling you the species and sex. RhODIS® can therefore be powerful at identifying 'linkages' between any two or more rhinoceros samples from an investigation (e.g. rhinoceros horn and an animal carcass; blood stained clothing and an animal carcass, etc.), providing irrefutable evidence in courts and linking crime scenes to suspected criminals. This means more successful prosecutions of poachers and traffickers.

To date, RhoDIS® has over 7,000 rhino samples and has contributed toward about 700 rhino investigative cases from east and southern African regions.

It has set the platform for new global forensic initiatives, investigations, and standards that enhances conservation efforts in the fight against global rhino crimes. It also promises to enhance rhino conservation and management in Asia: the Wildlife Institute of India (WII) is currently setting up a RhODIS® laboratory and a national Rhino DNA database for the greater one-horned rhino (*Rhinoceros unicornis*). In June 2016, the RhODIS® Rhino DNA Scientific workshop in South Africa, funded by USAID through the Wildlife-TRAPS Project and the WWF African Rhino Program, brought together wildlife DNA forensic scientists, enforcement officers and investigators from rhino horn source, transit and consumer countries. The meeting resulted in a simplified method to facilitate sharing and roll out of an improved RhODIS® compatible analysis system to laboratories across the world, which can become the international standard for producing comparable DNA profiles.

Tech Companies Collaborating to End Wildlife Trafficking Online

With increased global access to technology and connectivity along supply chain routes, the internet has become a thriving platform for buyers and sellers trading endangered wildlife products. As the United States and other countries ramp up regulations and enforcement to prohibit trade and raid physical wildlife markets, traditional shop and stall sellers are shifting their operations to the relative anonymity of web-based sales platforms internationally. There is an urgent need for a global illegal wildlife firewall, established by e-commerce and social media companies in partnership with conservation and law enforcement.

In April 2016 WWF, TRAFFIC and the International Fund for Animal Welfare (IFAW) brought together representatives from leading global tech companies to brainstorm solutions to illegal wildlife trade online. On August 12, 2016, seven partners, including eBay, Etsy, Gumtree, Microsoft, Pinterest, Tencent and Yahoo!, publically adopted a standardized wildlife policy framework to simplify shopping guidelines for consumers, identify prohibited products, eliminate the loopholes that make it easy for criminals to traffic wildlife online and present a united front from the tech sector. Several other companies aligned their policies internally to match this framework. In February 2017 Twitter also signed onto the global standardized wildlife policy framework.

The focus of this coalition is on eradicating illegal ads; working with online companies across the globe to enforce a unified, standardized policy framework that prohibits the trade in and promotion of illegal wildlife products on the web; partnering with online companies, their user networks, academia and conservation communities to mobilize millions of citizens to assist companies in detecting and reporting illegal wildlife products; and creating a global wildlife trafficking "Kill Switch." The Kill Switch will prevent illegal advertisements going live before they can be posted by targeting violators with a detection initiative between tech companies. Through new technologies, machine learning and data sharing, the e-commerce, social media, and online payment institutions will be able to identify and block criminals before they are able to list their product for sale. With regular, unwitting buyers out of the trade, criminals will be restricted to a much smaller marketplace on the dark web, the hidden part of the internet that exists on what is known as "darknets," which are overlay networks using the public internet but requiring specific software, configurations or authorization to access. The coalition efforts will actively target a shift from the surface web to the dark web, at which point law enforcement can deal with wildlife criminals operating there.

EXPANDING THE CONSERVATION TECHNOLOGY COMMUNITY

Technology offers enormous potential in securing a sustainable future for the planet. However, the conservation community faces a significant challenge in making sure these technologies are affordable and available to users around the world, and ensuring that people have the knowledge to use these tools properly. Even technologies that have already demonstrated their worth in the field must be adapted to specific social and environmental conditions, and require local buy-in and ownership. Ensuring that technologies can be adopted more widely requires resources, training and testing on the ground, often in challenging situations. However, too often the data and lessons learned from research and field tests are kept within NGOs, academic institutions or the private sector and are rarely shared effectively through peer-reviewed publications and media articles. Predictably, this leads to unnecessary duplication of effort as new technology users encounter the same challenges faced by others.

In November 2015, United for Wildlife, a partnership of Flora and Fauna International, IUCN, Conservation International, the Nature Conservancy, Wildlife Conservation Society, the Zoological Society of London, the Royal Foundation and World Wildlife Fund, with support from Google.org and ARM, launched a collaborative initiative called WILDLABS.NET to encourage and enable more open sharing of information about the use of technology to fight against illegal wildlife trade and the myriad other pressing issues facing our planet. It brings together a community of conservationists, technologists, engineers, data scientists, entrepreneurs and thought leaders. Community members share problems and successes, give and receive guidance, and access the resources needed to discover or collaboratively create technology to solve big conservation challenges. This online platform is enabling conservationists (including those based in the field) to connect directly with technology experts, explain the challenges they face and source technological solutions to these problems. Connecting with users on the ground will also help technologists test their ideas in field environments, and adapt them to ensure maximum possible impact. The WILDLABS.NET community has grown rapidly to over 1,300 global participating members. Members have been sharing ideas on a range of topics including new predator deterrents, using seismic detection technology to prevent human-wildlife conflict and tackling illegal logging with technology. They are collaboratively developing new hardware prototypes, including a new open-source acoustic monitoring device for tracking wolves and an automatic elephant detector using machine learning. They have also been crowd-sourcing answers to questions about low-cost tracking tags, integrating wildlife tracking with other technologies and self-powered camera traps, all the while sharing interesting conservation tech news and projects. By connecting people, WILDLABS.NET is putting knowledge and innovative solutions in the hands of the people working on the frontlines of conservation.

SCALING UP: A ROLE FOR THE PUBLIC AND PRIVATE SECTORS

Faced with increasingly sophisticated conservation challenges, 21st-century conservationists are being pressed to keep up, and technology and innovations are becoming increasingly essential tools in their toolbox. While exciting new innovations like the ones discussed in this testimony are already helping enhance our work, there is a world of innovation yet to explore in the field of conservation. And then there is the challenge of getting to scale: while WWF and its partners have been successful in testing and piloting new technological approaches, the conservation community alone will never have the resources needed to take these new technological tools to the level that is needed to have truly broad and transformational impact where it is needed most.

This will require the private sector to step in and step up in a big way, working with NGO partners.

It will also require continued investment by the US government, including maintaining robust congressional funding for current programs to combat wildlife trafficking, including the END Wildlife Trafficking Act and the National Strategy on Combatting Wildlife Trafficking, as well as support for biodiversity conservation around the globe through agencies including USAID, the US Fish and Wildlife Service and the Department of State. The US government should also explore potential new investments by non-traditional partner agencies, such as the Department of Defense, which may be able to repurpose new or existing technologies to aid in efforts to stop poachers and wildlife traffickers. More could be done to enable conservation groups to access or benefit from DARPA investments, Department of Defense research labs for anti-poaching or dual use technologies, and the downgrading of non-lethal military technologies to commercial use, allowing private sector ownership in the effort. The US government can also continue to spur innovation by expanding or building off of lessons learned from programs such as the USAID Wildlife Crime Technology Challenge and State Department-sponsored "hackathons" designed to crowd-source technological solutions to conservation challenges, including illegal wildlife trafficking and illegal fishing.

With continued commitment and additional investment from the public and private sectors, there are a range of priority conservation challenges we might tackle via technology and innovation, including:

- Leverage US technology experts and experts at the Defense Advanced Research Projects Agency to help solve the problem of "the needle in the haystack" when it comes to technology solutions used in the field and illegal wildlife being trafficked in shipping containers.

- Develop a technology to physically identify real horn or elephant ivory from alternatives or fakes, including hand-held scanners.

- Explore new technologies to generate visual recognition software that can identify and specify types of ivory from images in online sales.

- Continue to explore the most effective uses of UAVs, sensors and other remote technologies to create sophisticated, integrated systems for ranger patrols and anti-poaching efforts.

- Piloting the research and development of Internet of Things sensors to help stop poaching

CONCLUSION

In the end, technology is only a tool, not a silver bullet, and a tool is only as valuable as its user. Meeting our conservation goals will require sustained support and training for rangers, resource managers and community-based conservation activities. It will also require strong legal and regulatory structures that ensure wildlife is well-managed and that laws against poaching and illegal trade are well-enforced.

Without human resources behind them, not even the most advanced technologies can save species. And in our world of increasing technological sophistication, it is not just wildlife protectors but also wildlife poachers who are employing technology to make their work more effective and more efficient—which means that relying solely on traditional methods isn't just standing still, it's falling behind. But if we have the power of innovation backed by the resources of the public and private sectors, it is a race we can still win.

Senate Environment and Public Works Committee
Hearing entitled, "Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation"
March 15, 2017
Responses of Mr. Carter Roberts to Questions for the Record

Chairman Barrasso:

1. Mr. Roberts, since the establishment of the Wildlife Crime Technology Project, World Wildlife Fund has been able to partner and collaborate with a number of government entities and private partners. As a result, the Project has thus far successfully tested Unmanned Aerial Vehicles, digital monitoring systems, wildlife and wildlife patrol tracking devices, acoustic detection software, micro-radar for monitoring detection, and thermal cameras.

Are there any new innovative technologies you can share with us and the benefits you expect them to have?

Carter Roberts:

The focus of our Wildlife Crime Technology Project (WCTP) is to investigate cost-effective technology solutions that could be used by protected area managers, private landowners, and communities around the world to help stop and deter poaching. This presents the challenge of taking new or existing technology through a project cycle or innovation curve, which entails understanding the problem, identifying a potential technology solution, developing it, testing it, prototyping in the field, adapting, and finally deploying the technology.

Given that most poaching occurs at night, we identified the need to see at night as a high priority. We have found thermal technology to be successful in areas where there are long lines of sight – such as savannas and waterways. We are still in the testing and evaluation phase of the use of thermal cameras on UAVs – but they seem to work best when there is minimal forest canopy cover.

We are also testing and developing a wide variety of 'unattended' ground sensors – which means that they can operate and function as anti-poaching sensors that do not need rangers to be with them. This is a benefit as it then allows rangers to focus on other areas. In collaboration with partners, we have developed a prototype virtual radar fence that has an algorithm that can detect human movements. This type of sensor can potentially be used to monitor trails, or specific areas of potential poacher movement, and send alerts when humans are detected. Another type of sensor we have been exploring and plan on testing this year is a gunshot detector. We have been collaborating with Cornell University to develop a prototype that can be used outside of the United States.

One of the primary impediments to stopping poaching is the inability of parks to send signals or alerts of poaching activity in real-time. So another area of innovation we are exploring is use of low power, long-range wide area networks (LoRaWAN). This wide area network communications technology may allow us to connect radar, gunshot detectors, camera traps, and

tracking devices over long distances, especially in areas that do not have cell coverage, which is often true of large swaths of African parks. We have developed and tested ranger and vehicle tracking devices that run on a LoRa network. Preliminary testing found LoRa provides connectivity in excess of 20 kilometers radius of the LoRa gateway. We are collaborating with private sector partners to pilot this work in southern Africa.

We believe the combination of innovative unattended ground sensors, thermal cameras and ranger scopes, UAVs, and connectivity will provide meaningful and measurable deterrence to poaching that will increase in importance in the years to come. It should be noted that technology is only as useful as the rangers or security managers who use it. We have found that to get the best outcomes from using technology in the field, there must be commitment to training, re-training, and supporting rangers and field teams to use the technology.

Senator Booker:

2. Last month, the Journal of Mammalogy published a study titled "Adaptive use of nonlethal strategies for minimizing wolf–sheep conflict in Idaho" (a copy of this paper is included with the QFRs). During this seven-year case study on grazing operations on large, open-range federal lands in Idaho, researchers found that using a variety of nonlethal predator control techniques significantly reduced livestock losses compared to similar areas where lethal predator control was applied. The nonlethal predator control techniques included increasing the presence of guard dogs; hanging flags around the perimeter of a sheep herd (known as fladry); and using a setup of irregular flashing lights to mimic a human carrying a flashlight.

Based on your work in this area, can you describe other examples of new, nonlethal technologies and strategies that are being used to manage human-wildlife conflict internationally?

Carter Roberts:

Human-wildlife conflict (HWC) is a conservation issue for which there is no single solution because solutions are usually specific to the species or area concerned. Many of the most successful approaches are actually quite creative and simple. Strategies range from traditional approaches, such as the use of fences and noise to drive wildlife away, to technological innovations that detect and deter of wildlife, to the development with governments of policy strategies to address the root causes of the conflict. WWF is working on a wide variety of non-lethal HWC prevention and mitigation measures for species around the globe. Examples include land use planning that establishes denotes elephant corridors to prevent infrastructure and village development in vital migration corridors and to secure critical habitat; electric fencing of sled dog teams and secure food storage[1] to prevent polar bear depredation;[2] and predator-proof night corralling of goats against snow leopard depredation.[3]

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[1] www.samhao.nl/webopac/MetaDataEditDownload.csp?file=2:141193:1

[2] http://www.wwf.ca/?11881/Hamlet-of-Arviat-and-WWF-Canada-celebrate-success-of-Human-Polar-Bear-Conflict-Reduction-Project

[3] http://www.worldwildlife.org/projects/human-wildlife-conflict-mitigation-measures-in-nepal

The WWF report *Common Ground*[4] found that the most serious conflict and harm to both human communities and elephants resulted from unplanned and unregulated development that led to habitat loss and fragmentation. In Namibia, elephant-related conflict costs communal farmers around US $1 million a year, while in some Nepalese communities, it can be up to a quarter of the household incomes of poor farming families.

The most significant consequence of HWS is loss of human life, but other considerable psychological and social costs of human wildlife conflict go largely uncounted. To cite just one example, in Nepal, men in elephant-ravaged villages faced difficulties in marrying, as many women prefer not to move to villages where elephants are a problem. In some areas, retaliatory killing of elephants is a major threat to already vulnerable elephant populations.

The issue of human-elephant conflict (HEC) can be used to discuss some of the specific non-lethal approaches that have been successfully deployed. Elephants will often raid farmer's crops – wiping out months of effort and potential income. Each year, there are significant human and elephant deaths related to human-elephant conflict. In India, for instance, an average of 400 people and 100 elephants are killed each year due to HEC. These statistics vary from country to country.

WWF has employed a variety of non-lethal approaches to prevent, minimize, and mitigate HEC. These tools include the use of traditional and electric fencing, currently the most effective tool for keeping elephants out of crop fields and human habitations as long as they are carefully maintained carefully. In addition, across Asia and Africa, there have been efforts to use elephant-proof trenches (deep trenches dug with the intention of keeping elephants from getting across); text or siren alert systems to notify local communities when an elephant is approaching; and more traditional methods such as lighting fire crackers, making noise, and creating smoke screens. Making significant noise with the use of various tools such as drums, loud speakers, etc. is a technique many communities use to drive elephants away. Other tools include the use of chili as deterrents, from 'chili bombs' and 'chili guns', which is essentially throwing balls of ground up chili pepper (*Capsicum sp.*) at the elephant; using the noxious odor of chili smoke (a mixture of ground up pepper and elephant dung) to repel elephants; or using 'chili fences' – fences strung with chili-dipped fencing material to deter elephants. These tools have had varying degrees of success in several areas across Africa.

WWF has also been supporting the testing of quad-copter drones to buzz in front of problem elephants as they approach villages or community lands. The buzzing sound of the drone's electric propellers mimics the sound of buzzing bees – which the elephants have traditionally loathed. We are aware of several efforts to use quad-copter type drones to successfully move elephants away from areas where HEC may occur. However, it is important to note that elephants are extremely intelligent, and eventually find ways to overcome barriers placed in their way, from dropping logs onto electric fences to break the current, to cooperatively working in herds to move through trenches, and eventually losing their fear of noisemaking techniques such as the use of bee sounds once they realize there are no actual bees that follow suit. Therefore, it's

[4] http://wwf.panda.org/about_our_earth/all_publications/?133121/Common-Ground-Reducing-human-wildlife-conflict

important to constantly innovate tools and techniques to stay a step ahead of elephants to protect both them and the communities they come into conflict with.

In addition to techniques mentioned above, compensation to communities for their losses can be used as a mitigation measure, and insurance programs are used in certain locations to compensate insured communities for loss of life and for livestock lost to predators. The funding is created by a wide variety of mechanisms, but most require that the potential recipient pay for insurance.

'Common Ground' also identified giving rights over wildlife to local communities as an effective way to manage HWC by enabling local communities to benefit from neighboring wildlife. Economic analysis in Namibia demonstrated that these communities were able to generate more income from wildlife than they suffered from wildlife losses. In Nepal, communities that received benefits from wildlife and wildlife habitat showed a much greater tolerance towards elephants than communities receiving no benefits.

These are a few of the many non-lethal tools used across the world for conflict related to various species. While their use is important to address immediate needs, we must also look to addressing the root causes of such conflicts, such as habitat loss, if we are to reduce conflict over the long term.

3. What are some specific ways that more research funding in this area could help with identification and implementation of these new technologies?

Carter Roberts:

Many of the non-technology solutions we highlighted are predicated on the assumptions that a solution must be relatively easy to create and maintain, inexpensive, and created with local materials. Given these conditions, funding to support micro-credit programs for local communities to implement HWC techniques would be helpful. Similarly, support to organizations taking a lead in working with communities to develop and implement these techniques would enable them to scale up their work.

Additionally, funding to conduct additional research into the use of drone technology would be valuable. We have seen early promise in certain uses of drones. Funding to expand the testing and use of drones to develop best-management practices and protocols to prevent and mitigate HWC safely would be a worthwhile investment.

Senator Sullivan:

4. Mr. Roberts, Last year the Fish and Wildlife Service finalized its ban on the trade in African Elephant ivory to combat the market for ivory that drives the poaching crisis in Africa that is threatening the survival of African Elephants. While saving African elephants is a noble goal, unfortunately the FWS ban has spawned broadly written state ivory bans that, in California,

Hawaii, and New York among other states that broadly include walrus and mammoth ivory commonly used by many Alaska Native craftsmen and provide sorely needed income for rural cash based economies in Alaska. Last year I held a field hearing in Fairbanks, AK for the Subcommittee on Fisheries, Water, and Wildlife. At that hearing it became clear that there is still substantial confusion, particularly from tourists and potential carving purchasers over whether or not Alaska Native carvings and handicrafts—legally made under statutes like the Marine Mammal Protection Act—are banned by state or FWS laws and regulations. Further, we heard that this confusion has negatively impacted sales and peoples' livelihoods in my state. During hearing Mr. Roberts one of your employees Ms. Margaret Williams from the Alaska office for World Wildlife Fund committed to helping clear up the confusion on this important issue, and help make clear that Alaska Native works and mammoth ivory carving are not subject to the FWS's ban and legal to sell and buy in Alaska. Quote from transcript:

- "SENATOR SULLIVAN: And so just to clarify, would you -- would WWF help with getting the word out --
- MS. WILLIAMS: Yes.
- SENATOR SULLIVAN: -- to your members --
- MS. WILLIAMS: We'd be glad --
- SENATOR SULLIVAN: -- on this issue, because you have a powerful network?
- MS. WILLIAMS: We'd be glad to clarify. Yes, we would be glad to clarify the meaning of this ban and the importance of this…"Hearing Transcript, Subcommittee on Fisheries, Water and Wildlife for the Environment and Public Works Committee 46-47 (Oct. 20, 2017).

Is your organization still willing work to clarify the scope of the FWS's ivory ban? If so, has your organization taken any steps since October to clarify the meaning of the FWS ban compared to the state ivory bans?

Carter Roberts:

As noted in the question, nothing in the revised FWS rule on African elephant ivory will affect Alaska Native carvers working in walrus ivory or other traditional materials. The new federal rule applies only to African elephants and their ivory, and this has been clearly stated by FWS. The following can be found on the FWS website:

> *"This rule regulates only African elephants and African elephant ivory. Asian elephants and parts or products from Asian elephants, including ivory, are regulated separately under the ESA. Ivory from marine species, such as walrus, is also regulated separately under the Marine Mammal Protection Act (16 U.S.C. 1361 et seq.). Ivory from extinct species, such as mammoths, is not regulated under statutes implemented by the Service... [This rule] does not impose any documentation requirements for non-African elephant ivory."*
>
> (https://www.fws.gov/international/pdf/questions-and-answers-african-elephant-4d-final-rule.pdf)

As individual states consider taking action to address illegal wildlife trafficking and the elephant poaching crisis, as some states have already done, WWF's position has been that state governments should consider the federal approach in their state-by-state regulations and should engage with the co-management bodies – the Eskimo Walrus Commission and the US Fish and Wildlife Service – when considering potential regulations along these lines in order to avoid unintended outcomes.

WWF recognizes that US states have recently begun drafting and enacting their own state-level bans on the trade of ivory and that several states either do not define "ivory" in their regulations or include walrus, mammoth, and mastodon ivory in their state-level bans. In general, WWF does not work at the state-level in these places and has solely engaged on the federal rulemaking. However, WWF used its public testimony in October to make both scope of the FWS rule and our position on walrus ivory clear, including strongly encouraging all US states considering implementing their own ivory trade regulations to closely review the federal ban on trade of African elephant ivory and to consult with the Eskimo Walrus Commission and US Fish and Wildlife Service Region 7 Marine Mammals Management staff prior to drafting or enacting any state-level bans involving ivory. Our public recommendation has been that states consider the federal approach in their state-by-state regulations and engage with Alaska Native subsistence users when considering potential regulations along these lines in order to avoid unintended outcomes.

Since last October, WWF has taken further steps to disseminate our position on walrus ivory and to help clarify the scope of the FWS's ivory ban. We have added a page on "Ivory in the Arctic" to our website in order to educate our members and the general public on the issue. The text of that page is as follows:

> *WWF often communicates about ivory in our efforts to end unsustainable poaching of elephants for their tusks. In these communications pieces, WWF is referring to elephant ivory when using the term "ivory," unless otherwise specified. WWF tries to make this clear, but recognizes the word "ivory" refers to material from several species in addition to elephants, including mastodon and mammoth tusks, hippopotamus teeth, narwhal tusks, and walrus tusks. These types of ivory are exempt from the US federal elephant ivory ban, and it is legal for Alaskan indigenous people to hunt walrus and sell walrus ivory carvings. Many remote coastal communities in Alaska depend on walrus for food. Walrus are culturally and economically important for these communities, and the tusks are often carved into jewelry and artwork. Alaska's walrus population is co-managed by the Eskimo Walrus Commission and the U.S. Fish and Wildlife Service. WWF encourages decision makers to contact these co-management entities prior to enacting any legislation affecting use and sale of walrus ivory.*
>
> (https://www.worldwildlife.org/pages/ivory-in-the-arctic)

WWF has also engaged other environmental organizations that work at the state level on elephant ivory bans to request that they adjust their approach and advocate for policies that clearly focus on elephant ivory and/or clearly exclude walrus ivory from state-level prohibitions on commerce in ivory. Following last October's hearing, WWF reached out to the coalition of groups that have been advocating in states on elephant ivory bans specifically to raise and

address this issue. WWF staff participated in a call in late November with roughly a dozen of those organizations during which we elevated awareness among those groups around the bans' potential impact on walrus ivory carvers in Alaska and received assurances from representatives of several of those groups that their organizations would try to take a clearer approach in their ongoing state-level advocacy – one that would take Alaska Native concerns into account, would work to clarify the intent of the bans and would avoid advocating for overly broad language that could be interpreted to apply to walrus ivory. We also urged those groups to take care through their own public communications channels to use clear language making explicit that the federal rule affects only elephant ivory and to not imply, inadvertently or not, that the FWS rule could impact "ivory" from other species.

WWF recognizes and respects the culturally and economically important tradition of Alaska Native artists using the by-products of subsistence harvest to create and sell artwork. As a conservation organization, WWF is committed to working with people who depend on and value wildlife, to ensure that sustainable populations of key species remain intact for future generations of Alaskans. WWF's Arctic Field Program in Alaska will continue to work with the Eskimo Walrus Commission and other stakeholders in Alaska to further clarify our position on walrus ivory and how it differs from elephant ivory, as well as clarifying the limited scope of the federal regulations on elephant ivory. We encourage input from Alaskans, particularly those who rely on walrus for their cultural and nutritional needs.

Senator BARRASSO. Well, thank you very much for your testimony, Mr. Roberts.

We will now turn to Kim Kurth, who is the Acting Director of the Fish and Wildlife Service.

Thanks for joining us.

STATEMENT OF JIM KURTH, ACTING DIRECTOR, FISH AND WILDLIFE SERVICE

Mr. KURTH. Thank you, Chairman Barrasso, Ranking Member Carper, and members of the Committee for the opportunity to testify on innovations and partnership that support wildlife conservation.

The Fish and Wildlife Service works with our partners to ensure current and future generations are able to enjoy the diversity of wildlife of America. Their enjoyment can take many forms, whether it is through hunting and fishing, wildlife observation, or even just the knowledge that wildlife exists.

Conserving wildlife is a complex endeavor. To address challenges ahead, the Fish and Wildlife Service must work effectively with our partners, both public and private, across both large and small landscapes.

We have seen great successes, but we realize there is still work to do in the future. My written testimony touches on a number of the ways we are working to transform the way we deliver conservation to benefit fish and wildlife species, and the people and communities who inhabit the landscapes with them. I will share just a few examples with you here.

Successful long-term conservation depends on a collaborative effort that focuses on both public and private lands. The primary tool for collaboration with private landowners that the Service uses is our Partners for Fish and Wildlife program. Many private landowners are eager to work with the Service to help them to be the best possible stewards of their land they can. The Partners program has worked with more than 50,000 willing landowners since 1987 to provide financial and technical assistance to improve habitat and productivities on millions of acres of private lands, benefiting hundreds of species of native fish and wildlife, and we look forward to the opportunities that lie ahead.

Invasive species present a major threat to native fish and wildlife species, as well as to the economy. The Service has worked to develop innovative partnerships, management techniques, and technological advances to control the spread of invasive species, attempt to eradicate them, and to prevent their introduction into sensitive areas.

Invasive species are a constant threat, so the Service has worked to streamline its injurious species listing process under the Lacey Act and develop decision-support tools to help us prevent further introduction of invasive species. This includes a peer-reviewed model to help us as quickly predict the species most at risk of becoming invasive here in the United States.

We are also using molecular-based surveillance technologies, such as environmental DNA, or eDNA, to detect invasive species earlier in the invasion process. We are the lead Federal agency implementing eDNA monitoring to detect the spread of invasive Asian

carp in the Chicago area waterway system and in the Great Lake tributaries.

We have developed invasive species strike teams, highly trained rapid responders who deploy to national wildlife refuges across the Country to attack new outbreaks of invasive species before they gain a foothold, cause major damage, and subsequently cost taxpayers dollars.

In Wyoming, we are working with local landowners and conservation partners to investigate the effectiveness of naturally occurring weed-suppressing bacteria to combat cheatgrass infestations. Research is underway in the State to better understand the usefulness of these biological controls.

Combatting wildlife trafficking is another area of the Service's work where we are developing innovative solutions. With wildlife crime threatening wildlife populations, we are partnering with law enforcement using advanced evidence collection, forensics analysis, and intelligence to target and disrupt criminal organizations involved in poaching and wildlife trafficking.

This work also includes technology to detect poaching, detection dogs to track evidence from poaching scenes and find illegal wildlife in shipments, and new genetic analysis techniques to identify the geographic origin of seized wildlife products.

We have also established innovative public-private partnerships with Jet Blue and Discovery Communication to raise awareness for wildlife trafficking and drive down consumer demand for illegal wildlife products.

Simply put, our mission to sustain America's natural heritage for the enjoyment of future generations depends on our ability to strengthen and expand our partnership work, using the latest innovations in technology and wildlife management practices.

Thank you again for the opportunity to testify, and I would be happy to answer your questions at the end of the panel. Thank you.

[The prepared statement of Mr. Kurth follows:]

Testimony of Jim Kurth, Acting Director,
U.S. Fish and Wildlife Service, Department of the Interior
Before the Senate Committee on Environment and Public Works on Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation

March 15, 2017

Good morning Chairman Barrasso, Ranking Member Carper, and Members of the Committee. Thank you for the opportunity to appear before you today to testify on the U.S. Fish and Wildlife Service's (Service) work to develop innovative solutions to control invasive species and promote wildlife conservation. My name is Jim Kurth and I am the Acting Director for the Service within the Department of the Interior.

The Service's mission is "Working with others to conserve, protect, and enhance, fish, wildlife, plants, and their habitats for the continuing benefit of the American people." To maximize our effectiveness the Service continually seeks to partner with others and to innovate. The Service has developed innovative solutions to conserve wildlife and control invasive species by: collaborating with others and leveraging resources through partnerships; using the best available science to inform and adapt our management approaches; and employing innovative technologies to achieve our mission. Our testimony will describe innovative work the Service does in a number of areas ranging from engaging with private landowners through the Partners for Fish and Wildlife program and other wildlife conservation partnerships, to preventing and controlling the spread of invasive species, to combating the illegal wildlife trade.

Collaborating for Conservation

"Working with others" is at the forefront of the Service's mission. In all of the Service's work, we recognize that the conservation of our nation's fish and wildlife is not something that the Service can achieve on its own. Strong partnerships with state and federal agencies, Tribes, private landowners, and other stakeholders are integral to achieving conservation successes. These diverse partnerships are a force multiplier, bring new resources and viewpoints to the Service's work, allowing us to leverage conservation dollars and expand our knowledge.

Partners for Fish and Wildlife Program

It is critical that the Service engage with private landowners to collaboratively develop and achieve wildlife conservation goals. A primary tool for collaboration with private landowners is the Partners for Fish and Wildlife (Partners) program. The Partners program, founded in 1987 and celebrating its 30th anniversary, offers voluntary habitat restoration and enhancement options that are tailored to mutually benefit both wildlife and landowner needs. The program requires a cost share – an investment of private landowner funds, land, or other services to complement federal funds. It has had no shortage of participants, and in fact there is a large backlog of hundreds of landowners who want to participate in the program. In South Dakota, for example, there are nearly 150 landowners would like to participate.

Since the Partners program's inception, these voluntary incentive-based efforts have resulted in over 4.5 million acres of uplands, 1.2 million acres of wetlands, and more than 13,000 miles of

stream habitat restored and enhanced across the nation. This work was completed in partnership with nearly 50,000 private landowners.

The Partners program contributes to the economies of many rural communities in order to harmoniously balance landowner objectives with wildlife habitat and ensure that the needs of people and wildlife are met for future generations. According to a published 2014 economic analysis report, the Partners program leverages more than $8 in non-federal funds for every Federal dollar invested in the program, which multiplies to $15.70 in economic returns and supports over 3,500 jobs nationwide.

This emphasis on partnership-driven conservation and working together to preserve working landscapes has built and strengthened community trust and support for our work across the nation. The Partners Program takes that model of trust and credibility and uses it to foster relationships that work to downlist, delist, and prevent listing of species under the Endangered Species Act (ESA).

The Partners program has facilitated the restoration of healthy waterways across the nation, benefiting populations of federally-listed fish species and valuable game fish such as salmon, native trout, smallmouth bass and muskellunge. Conservation on private lands complements and leverages the benefits of national wildlife refuges and other protected areas by providing and connecting important fish and wildlife habitats. Preserving working landscapes benefits both species and traditional land uses, such as farming and ranching.

Coastal Program

The Coastal Program is another example of a voluntary, cost-share, partnership-based program, and it is the Service's primary tool for community-based fish and wildlife habitat conservation on public and privately-owned land. The program delivers both technical and financial assistance, conservation planning and on-the-ground coastal habitat restoration. Through partnerships, the Service leverages its technical and financial resources with partner resources to maximize habitat conservation and benefits to federal trust and other priority species. In 2016, working with 462 partners and landowners on 280 projects, the Coastal Program assessed and improved more than 16,000 acres of wetlands, 50,000 acres of upland and 100 miles of stream habitats, leveraging $25 for every Coastal Program project dollar.

Partnerships with States and Tribes

The Service has developed additional innovative mechanisms to cooperate with states, private landowners, and others, both to preclude the need to add species to the threatened and endangered list where possible, and to speed the recovery of those species that are listed under the ESA. State fish and wildlife agencies are essential partners in implementing the ESA, with which the Service works closely on proactive conservation to prevent the need for the regulatory mechanisms of the ESA. If listing is needed, state agencies are critical to monitoring species, fostering public awareness in their communities, and carrying out on-the-ground recovery actions. Some of the most recent successes include the Sonoran desert tortoise, New England cottontail rabbit, and the Montana arctic grayling, each of which was precluded from listing due to successful, proactive conservation efforts with our partners.

When species do warrant the protections of the ESA, the Service will commit to collaborating with state and tribal agencies to most effectively recover those species. In our efforts to recover the endangered black-footed ferret, the Service has partnered with the Wyoming Game and Fish Department (WGFD), Lower Brulé Sioux Tribe in South Dakota, and private landowners to reintroduce ferrets on the landscape. Through sustained recovery efforts, Service partnerships with state and Tribal governments, other Federal agencies and private landowners have largely contributed in recovering at-risk populations. These conservation efforts have culminated in the delisting of several recovered species, including several recent examples such as the Louisiana black bear, Oregon chub, and Delmarva fox squirrel, and to this day, their numbers remain at stable levels.

Another important area in which the Service partners with the states is our work to support vibrant waterfowl hunting opportunities, utilizing modeling and adaptive management. Migratory birds are cooperatively managed by the Service and the State and Canadian Provincial wildlife agencies through four administrative migratory bird "flyways". Each Flyway has a Council consisting of representatives from state and provincial agencies, which works in partnership with Service to develop hunting seasons and bag limit frameworks. The States then choose their individual hunting seasons based upon these annual hunting frameworks. In addition, in 1987 the Service started the Migratory Bird Joint Ventures, which are cooperative, regional partnerships that work to conserve habitat for the benefit of birds, other wildlife, and people. The 22 Joint Ventures, which cover most of the country, work to provide scientific tools and greater scientific understanding of birds in the landscape and how to protect and conserve them.

Working Lands for Wildlife

We also partner with Natural Resources Conservation Service (NRCS) to implement the program Working Lands for Wildlife, which focuses on voluntary conservation on working landscapes. Through this voluntary, incentive-based Working Lands for Wildlife effort, NRCS and Service programs provide landowners with technical and financial assistance to achieve specific conservation goals for candidate and listed species. Since 2012, the NRCS has restored and protected 6.7 million acres of important habitat for a variety of wildlife. These efforts have led to the rebound of many species, demonstrating the Working Lands for Wildlife conservation model works.

Partnerships with the Military

Another example of a Service partnership enabling innovative wildlife and habitat management is our work with the Department of Defense and states under the Sikes Act. Military lands comprise approximately 25 million acres and are largely undeveloped. These lands represent diverse habitat types that in many cases support among the highest levels of biodiversity of any other federal land types. Defense installations work with Service and state counterparts to develop integrated natural resources management plans (INRMPs) for their installations. INRMPs support the military mission of each installation while also improving access to hunting, fishing, trapping, and other outdoor recreational opportunities for military communities and the public, and maximizing the conservation benefits of these lands for wildlife species. A partnership between the Service, Air Force, and Marine Corps to manage the endangered Sonoran pronghorn population recently brought back this endemic species from 21 to 202

animals. In 2013, the Service and Air Force established a national interagency agreement to support the management of natural resources on Air Force lands. The Service now provides technical assistance and expertise to over 45 Air Force installations. This partnership has improved management decisions for approximately 125 listed species and their habitat, meeting the core missions of both agencies while reducing regulatory burdens.

Sentinel Landscapes

Another example of our work with the Military is the Sentinel Landscapes program which is a partnership between the Department of Defense, the Department of Agriculture, and the Department of the Interior. Sentinel Landscapes are working or natural lands important to the Nation's defense mission – places where preserving the working and rural character of key landscapes strengthens the economies of farms, ranches, and forests, conserves habitat and natural resources, and protects vital test and training missions conducted on those military installations that anchor such landscapes. First established in 2013, the Sentinel Landscapes Partnership is a nationwide federal, local and private collaboration dedicated to promoting natural resource sustainability and the preservation of agricultural and conservation land uses in areas surrounding military installations. Agencies from the three Departments coordinate the Partnership at the national level through the Sentinel Landscapes Federal Coordination Committee. The Sentinel Landscapes Partnership seeks to recognize and create incentives for landowners to continue maintaining these landscapes in ways that contribute to the nation's defense. Where shared interests can be identified within a Landscape, the Partnership coordinates mutually beneficial programs and strategies to preserve, enhance or protect habitat and working lands near military installations in order to reduce, prevent or eliminate restrictions due to incompatible development that inhibit military testing and training.

Controlling Invasive Species

Invasive species can be introduced in a myriad of ways, from the illegal release of non-native species to the discharge of ballast water from ships. The adverse consequences from invasive species range well into the tens of billions of dollars each year in natural and economic damages in the U.S. alone. Additionally, invasive species have interfered with the recovery or contributed to the decline of 42 percent of federally listed threatened and endangered species. This can lead to increased regulatory burdens to the public. To keep pace, the Service has sought to innovate in the areas of partnerships, management, and technology in the areas where we have influence, including in aquatic systems, on national wildlife refuges, conservation of federally protected species, and the inspection of wildlife trade.

Prevention

With the increasingly global nature of our economy and transportation systems, the importation of potentially invasive species into the U.S. will continue, as will the risks—and costly impacts—they impose on our economy, environment, and public health. Preventing the introduction and spread of harmful species is the most cost-effective approach to eliminating or reducing these threats. Title 18 of the Lacey Act is an important authority the Service uses to prevent the introduction of invasive species through the trade of live organisms and through other pathways. The Service may list a species as injurious through the regulatory process, thus prohibiting its importation or its transportation between States, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the U.S. without a permit issued

by the Service. In 2016, the Service designated 11 nonnative aquatic species proactively to avoid them from potentially becoming invasive species in the U.S. With tens of thousands of species in trade in the U.S. alone, the Service has worked to streamline its injurious species listing process and develop decision-support tools, such as risk screening. This allows the agency to quickly evaluate the relative risks associated with particular species and prioritize them for further evaluation.

The Service uses international databases and scientific papers that are readily available online to produce rapid screening reports called Ecological Risk Screening Summaries. The information is used in a peer-reviewed model that matches the basic climate requirements in the species' native and introduced ranges with similar climates in the U.S. Along with the climate match, the reports provide information on the species' history of invasiveness. Combined, the two factors provide a good prediction of the risk of invasiveness in the U.S. These reports are posted online to provide the live-animal trade industries with the necessary technical information to help them voluntarily decide which species to refrain from importing. In addition, State natural resource and conservation agencies can use the rapid risk screening reports to aid with their own management of potentially invasive species as well as management in coordination with industry.

Detection

While preventing introduction and establishment is the Service's highest priority for invasive species management, we recognize that too many introduction pathways exist to completely and cost-effectively prevent invasion. One thing is clear—the earlier an invasion is detected, the more cost-effective and successful management actions will be. Molecular-based surveillance technologies, such as environmental DNA, or eDNA, and next-generation sequencing, have shown significant promise in detecting invasive species early in the invasion process. eDNA can be left in the environment in the form of scales, cells, feces, or mucus. The Service maintains and annually updates the Quality Assurance Project Plan that serves as the standard protocol for the collection and processing of eDNA samples. The Service has also been the lead federal agency for eDNA monitoring for invasive Asian carp in the Chicago Area Waterway System and Great Lakes tributaries since 2013. eDNA samples are processed at the new state-of-the-art Whitney Genetics Lab in Onalaska, Wisconsin, part of the Service's Midwest Fisheries Center. To target specific species of carp, the Service worked with states and Canada on a regional eDNA surveillance program to determine the presence or absence of genetic material from silver and bighead carps.

The Service has also supported non-traditional detection methods, such as detection dogs. The Service has supported the training and use of dogs to detect the presence of microscopic zebra and quagga mussel larvae that cannot be seen with the naked human eye, which hitchhike to new habitats in or on boats. This ancient, natural canine sentry-technology can be more effective than any technology humans have devised.

Eradication

The Service has also developed Invasive Species Strike Teams, which are used to attack new outbreaks of invasive species before they obtain a foothold and cause major damage. These rapid responders are highly trained individuals deployed to national wildlife refuges across the country as soon as an invasive species infestation is detected. This accomplishes invasive species

eradication for a fraction of the cost of what would be involved if the invasive species were allowed time to become fully established in an area; we are saving taxpayers money and native species through early detection and rapid response. These Service Strike Teams have partnered with Tribes, private landowners, the National Park Service, and youth conservation groups to coordinate their strategy of "early detection and rapid response." For example, in 2015, the Montana/Wyoming Strike Team surveyed 2,500 acres for new invasive plants at the National Elk Refuge and treated 87 new invaders on 87 acres.

While invasive species are a continuing and urgent threat to native plant communities and wildlife habitat across the country, the Service has collaborated on many success stories in the control and eradication of invasive species.

Within the Great Lakes region, the Service has been working with the Great Lakes Commission on the binational Great Lakes Sea Lamprey Control Program for more than 50 years. Lampreys have been enormously destructive since they invaded the Great Lakes from the Atlantic Ocean in the 1930s. During its life, a parasitic sea lamprey can kill 40 or more pounds of fish; they parasitize lake trout, whitefish, and other species, which was a major factor leading to the collapse of Great Lakes fisheries in the 1950s. The Service is the primary agent implementing control activities, using integrated pest management techniques to suppress sea lamprey populations to less than 10 percent of numbers experienced during the 1950s collapse. Control of this harmful species has allowed for the reestablishment of sport and commercial fisheries that have recently been estimated as having an annual value of $7 billion. The Service co-chairs the Asian Carp Coordinating Committee (ACRCC) to prevent the introduction and establishment of Asian carp in the Great Lakes. The work of the ACRCC is outlined in its 2017 Action Plan, which contains a portfolio of over 60 high-priority strategic activities planned for implementation in the coming year, including continued support for contingency response plans. The Action Plan serves as a foundation for the work of the ACRCC partnership — a collaboration of 27 U.S. and Canadian federal, state, provincial, and local agencies and organizations — working collaboratively to achieve its mission.

In the northeastern U.S., the Service has partnered with the Animal and Plant Health Inspection Service (APHIS) to eradicate to near-zero the invasive nutria from the Blackwater National Wildlife Refuge and adjacent lands in Delaware, Maryland, and Virginia. These large rodents have destroyed thousands of acres of marshland on the Delmarva Peninsula through their destructive feeding habits. One of our most effective tools has been working with USDA to deploy specially trained detection dogs that are able to track down nutria. This eradication progress would not have been possible without cooperative partnerships with USDA and public and private landowners including Delaware Department of Natural Resources and Environmental Control, Maryland Department of Natural Resources, Virginia Department of Game and Inland Fisheries, and Tudor Farms.

In Oklahoma, the Service helps with trapping and controlling invasive feral swine in partnership with other federal agencies. The Service also applies integrated pest management practices in Oklahoma on salt cedar and other invasive plants in partnership with multiple organizations and private landowners.

Across the American West, the invasion of non-native plants like cheatgrass and medusahead, and the cycle of extreme wildfires they promote, is one of today's most important land management issues. The invasion of these exotic annual grasses into sagebrush habitats in Wyoming and elsewhere has resulted in more frequent and extreme wildfires, accelerating habitat loss and threatening the health of the greater sage-grouse and other sagebrush-dependent species. With the limited success of traditional mechanical and chemical efforts to treat annual grass invasion over the past 50 years, the Service is working with USDA's Agricultural Research Service, the Bureau of Land Management, the U.S. Geological Survey (USGS), and other partners on a new tool to manage these invasive grasses: a naturally occurring weed-suppressing bacteria, *Pseudomonas fluorescens* (*P. fluorescens*), to be utilized as a host-specific biopesticide. Field trials were initiated in 2015 at the Mid-Columbia National Wildlife Refuge Complex in Washington State to test the bacteria's efficacy.

In Wyoming, the Service has worked with local landowners and conservation partners to investigate the effectiveness of chemical and biological treatments, including *P. fluorescens*, to combat cheatgrass infestations. Three separate trials are underway in the state to better understand the usefulness of biological controls as a stand-alone treatment or in conjunction with more traditional chemical controls. In addition, the Seedskadee and Cokeville National Wildlife Refuges in Wyoming, working together with long-standing private and public partners, have also been treating invasive plants, including cheatgrass, salt cedar and Russian olive, with use of prescribed grazing as well as chemicals.

USGS recently released a restoration handbook that provides practical guidance for landowners and land managers on how to restore sagebrush ecosystems and control invasive plants, such as cheatgrass. This handbook describes specific restoration treatment options for controlling cheatgrass through use of targeted grazing that takes into consideration when, where, and how long grazing needs to occur to help eliminate cheatgrass.

In Colorado and Nebraska, we have leveraged voluntary agreements to partner with state and local governments, as well as private landowners, to treat the invasive salt cedar and Russian Olive plants. This work improves habitat for the endangered southwestern willow flycatcher, the threatened yellow billed cuckoo, and other migratory birds and wildlife.

Partnerships to Address Invasive Species

The Service also relies on partners to control, manage, and prevent invasive species introductions. As a co-chair of the Aquatic Nuisance Species Task Force (Task Force) the Service guides the work of its members through a strategic plan. Collaborating with 13 federal partners and 14 nonfederal organizations, the Service works to combat the introduction and spread of aquatic invasive species through species specific control plans for quagga and zebra mussels, Asian carp, and other species. Through the Task Force, the Service also created regional panels that provide a host of services and products that foster communication and collaboration. Overall, the Task Force provides a national infrastructure and forum for collaborative discussion and decision making on important issues that can impact prevention, control, and management of invasive species at federal, state, and local levels.

Also, the Service continues to work with boat and equipment manufacturers to develop guidelines and best practices to reduce the likelihood of spreading aquatic invasive species through boating activities. For example, work is underway to assess water temperatures and pressures that will eliminate invasive mussels while avoiding impacts to marine motors and pumps. Results of this work could lead to voluntary industry standards that assist with the decontamination of boats.

Another effective vehicle for partnerships to control the spread of invasive species is the Wildlife and Sport Fish Restoration program, through which the Service provides funding to state partners to address invasive species at the local level. Waterbody inspection stations, funded through the Dingell-Johnson Sport Fish Restoration Act, are eligible projects that help to eliminate the transfer of aquatic nuisance species transfers from one waterbody to another.

Combating Wildlife Trafficking

Wildlife trafficking is a multi-billion-dollar illegal trade driven by criminal syndicates that are highly organized, violent, and capable of moving large, commercial volumes of wildlife and wildlife products through global trade routes. This illegal trade threatens the survival of thousands of wildlife species, including some of the world's most iconic animals such as elephants and rhinos, as well as less well-known species such as pangolins, tortoises, and parrots.

We are working alongside 16 other Federal departments, including our co-chairs, the Departments of State and Justice, and agencies to bring a whole-of-government approach to combating wildlife trafficking, leveraging resources and expertise to more efficiently and effectively curb poaching and illegal trade.

International Conservation

The Service manages several grant programs focused on international conservation, and we are using these programs to address critical conservation needs in innovative ways.

Cooperation within the U.S. government and among nations is essential to combat wildlife trafficking and we are finding new ways to work effectively together. With assistance from the State Department, we created the first program for stationing Service regional wildlife law enforcement special agents at U.S. embassies as attachés. They are now stationed in Thailand, Botswana, Peru, Tanzania, China, and Gabon, and provide investigative support to partner countries, facilitate information sharing, and provide much needed training in areas such as crime scene processing and evidence collection, wildlife identification, technical investigative techniques, and handling and processing of digital evidence.

Investigative Tools

Given the sophisticated nature of the criminal syndicates and smuggling networks involved in wildlife trafficking today, the Service's Office of Law Enforcement is responding with equally sophisticated investigations to catch these criminals and disrupt their operations. Our inspectors and agents utilize intelligence to intercept wildlife contraband, conduct proactive enforcement operations to catch smugglers, and investigate businesses and individuals engaged in illegal activities. For example, an ongoing nationwide criminal investigation known as "Operation Crash" has led to 41 arrests, 30 convictions and the seizure of smuggled elephant tusks and rhino

horns with a street value in excess of $75 million, and we expect more results as this investigation continues. In addition to wildlife crimes, the defendants also have been charged with money laundering, tax evasion, falsifying documents, mail fraud and bribery.

Domestic Poaching and Illegal Trade
Unfortunately, the United States is increasingly becoming a source country for illegally traded wildlife and wildlife products, threatening our domestic wildlife populations with increased poaching. Some of the domestic wildlife we are seeing targeted for illegal global trade include freshwater turtles, reptiles, eels, coral, and the caviar from paddlefish and sturgeon. The Service is using our same innovative investigative techniques and working closely with the states to combat these crimes. For example, working closely with a dozen states and several other Federal agencies, the Service led an investigation known as "Operation Broken Glass", which focused on the illegal trafficking of juvenile American eels on the East Coast, which are highly prized in Asian seafood markets. To date, the investigation has resulted in guilty pleas for 10 individuals, involving more than $2.6 million worth of juvenile eels.

The Service also works closely with our state and tribal partners to enforce wildlife laws and address domestic poaching unrelated to wildlife trafficking. For example, in collaboration with the National Park Service and the State of Alaska, we led an investigation that focused on an illegal commercial hunting and guiding syndicate. The investigation uncovered that a cable television show, "Syndicate Hunting", and nine other individuals illegally guided and hunted in the Noatak National Preserve where they unlawfully killed grizzly bear, moose, caribou, and Dall sheep. The investigation resulted in nine federal convictions, prison terms, and hundreds of thousands of dollars in fines, restitution penalties, seized trophies and equipment. The Service also provides trainings and workshops for state and tribal game wardens to enhance collaboration, share information, discuss best practices, and strategize on new and innovative approaches to wildlife law enforcement.

Public-Private Partnerships
Efforts to combat wildlife trafficking must attack the entire trade chain, including reducing consumer demand for illegal wildlife. The Service has established innovative public-private partnerships to reach new audiences and empower consumers, including with JetBlue and Discovery Communications. These partnerships help us reach millions more consumers from a variety of audiences with educational messages that can help raise awareness of the wildlife trafficking crisis and drive down demand for illegal wildlife products in the U.S. and abroad.

Using Innovative Technologies for Efficient and Effective Conservation
The Service aims to use innovative approaches to management that move the needle on conservation, enhance ecosystem resilience, and efficiently use taxpayer dollars. For example, the Prime Hook National Wildlife Refuge marsh restoration project in Delaware is a collaborative effort to improve habitat for wildlife and help ensure the safety of people living in nearby coastal communities. Supported by $38 million in federal funding from the Hurricane Sandy Disaster Relief Act, the project is one of the most complex restoration efforts ever attempted on the U.S. East Coast. It employed state-of-the-art science and computer modeling to restore habitat, reestablish natural tidal water circulation, and enable salt marsh vegetation to return and flourish. The project will improve the resiliency of the coastline to the impacts of sea-

level rise and intense storms, while providing valuable wildlife habitat and protecting the local community.

The National Fish Passage Program (NFPP) works through partnerships to remove aquatic barriers with inventive infrastructure, creating more resilient and efficient systems for aquatic species and local communities. NFPP is a completely voluntary program that brings together a broad diversity of stakeholders; on average, the fish passage program leverages from outside sources more than three times the amount of funding it receives from the Service. Using innovative hydrological and construction designs, the NFPP rebuilt two water diversions on the South St. Vrain Creek in Boulder, CO, due to a 2013 flood. These advanced diversions leave more water in the system for aquatic species and other water users.

The Service works to incorporate state-of-the-art technology into its management practices in other ways to achieve cost-effective conservation. For example, as part of a pilot project, the Service used unmanned aircraft systems (UAS) in lieu of planes to survey waterbird populations at three national wildlife refuges in California and Nevada. The cost-effective UAS technology improved safety conditions for biologists and minimized disturbance of birds. This is just one of many examples that illustrate the Service's commitment to innovation and ingenuity.

Conclusion

The conservation challenges our nation faces demand that the Service remain focused, effective, and innovative. We must be nimble and strategic in identifying and embracing opportunities that enhance our ability to carry out our mission and conserve our wildlife heritage for the enjoyment of current and future generations of Americans. The examples discussed in our testimony demonstrate how the Service focuses on leveraging our capacity, building partnerships, and developing innovations in technology and management approaches.

Thank you for your interest in exploring solutions to promote wildlife conservation and control invasive species. We appreciate the opportunity and look forward to working with the Committee on ways to further the Service's innovative approaches to management and use of technology to further the conservation mission.

Committee on Environment and Public Works
406 Dirksen Senate Office Building
Wednesday, March 15, 2017
10:00 am

Hearing on
"Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation"

Mr. Jim Kurth

Question from **Senator Kamala Harris (D-CA)** for Mr. Jim Kurth, Acting Director, U.S. Fish and Wildlife Service

1. In Lake Tahoe, a region that borders the States of California and Nevada, an invasive species called the quagga mussel threatens the ecosystem and the livelihood of the surrounding community, whose economy largely depends on the recreation and hospitality industry. The U.S. Army Corps of Engineers recently estimated that in Lake Tahoe's case, quagga mussel infestation can cost the region $22 million annually from potential damage to tourism, reduced property values, and increased maintenance costs. In last year's *Water Infrastructure Improvements for the Nation Act* that my EPW colleagues led, there was a specific provision that was included that supported management of invasive species like the quagga mussel.

   From the funding that resulted in that legislation, what capacity has the Fish and Wildlife Service used those funds for the improvement of Lake Tahoe? More broadly, what best practices and policies do you that can be applied nationwide to areas like the Great Lakes?

   Response: Under the current continuing resolution the Fish and Wildlife Service (Service) has not received funding for zebra/quagga mussel management under Water Infrastructure Improvements for the Nation Act. However, a number of ongoing Service efforts benefit mussel prevention initiatives within Lake Tahoe. For example, the Lake Tahoe Interstate Aquatic Nuisance Species (ANS) Management Plan approved by the ANS Task Force receives annual funding from the Service. The ANS Task Force also developed the Quagga/Zebra Mussel Action Plan (QZAP) to address the invasion of zebra and quagga mussels in the Western States. Since 2012, the Service has allocated over $900,000 annually under QZAP to focus on priority spread prevention projects.

Question from **Senator Dan Sullivan (R-AK)** for Mr. Jim Kurth, Acting Director, U.S. Fish and Wildlife Service

2. **Can you discuss any efforts your office has taken or will take to clear up the confusion over whether the Service's African Elephant Ivory ban covers walrus and mammoth ivory crafts Alaskans make and sell?**

   Response: We are aware that there is some confusion, which we believe is due in large part

to proposed and recently enacted State laws banning the sale of many types of ivory, including walrus and mammoth ivory in some cases. We have provided information to clarify that the actions taken by the Service, under Federal law, with regard to African elephant ivory, do not apply to ivory from other species. The Service developed a "What can I do with my ivory?" section on our web site to present this information to the public (https://www.fws.gov/international/travel-and-trade/ivory-ban-questions-and-answers.html). We have worked with the Indian Arts and Crafts Board (IACB) and also provided information through our outreach to the Alaska Native Arts Advocacy Group, Kawerak Inc., the Eskimo Walrus Commission, other partners and the public.

Walrus ivory is regulated under the Marine Mammal Protection Act, which specifically allows for sale of authentic native handicrafts, and the Service has provided information on that issue on our "Traveling to Alaska" webpage (https://www.fws.gov/international/travel-and-trade/traveling-to-alaska.html). We look forward to continuing to work with the IACB and others to help ensure that consumers are informed and feel comfortable purchasing authentic native handicrafts.

Senator BARRASSO. Well, thank you so much for being with us and sharing your thoughtful testimony.

I would like to now turn to Dr. Jamie Reaser, who is Executive Director of the National Invasive Species Council, the U.S. Department of Interior.

Thanks for joining us.

STATEMENT OF JAMIE K. REASER, PHD, EXECUTIVE DIRECTOR, NATIONAL INVASIVE SPECIES COUNCIL (NISC) SECRETARIAT, U.S. DEPARTMENT OF THE INTERIOR

Ms. REASER. Mr. Chairman, Ranking Member Carper, members of the Committee, thank you for the opportunity to appear before you today at this hearing on innovations in fighting invasive species and conserving wildlife. This is a particularly important topic for the National Invasive Species Council, since fostering innovation is one of the Council's priority areas of work.

I will summarize my written testimony, which has been provided for the record.

Invasive species pose threats to all aspects of national security and well-being, and have particularly devastating impacts on the environment, health, infrastructure, and the economy. The National Invasive Species Council, known as NISC, is the interdepartmental body charged with providing the vision and leadership necessary to coordinate, sustain, and expand Federal efforts to safeguard the interests of the United States from the impacts of invasive species. The Council is comprised of the senior-most leadership of 13 departments and 3 White House offices.

As you know, the invasive species issue is complex and challenging. It requires a unified, coordinated approach across all levels of government and in partnership with affected communities. It also requires a "we can do this" perspective. Investments in technology innovation can be game-changing. They are demonstrating that seemingly insurmountable challenges can be overcome with substantial returns on investment. Technology innovation is helping us change the conversation from "can't" to "can" and "let's get it done now."

The current priorities of the Council's work to advance technology innovation are included in my written testimony. I would like to make a few general points about technology innovation in the context of invasive species.

First, in order to be effective, advancements in technology innovation don't require substantial investments in time or money. There are numerous low-tech innovations being made with relatively rapid, cost-effective outputs.

Many of the technologies that exist that could help us prevent, eradicate, and control invasive species already exist, but they were developed for other applications.

Opportunities are emerging to put a comprehensive toolbox together to address some of the most important invasive species challenges.

Fourth, best practices for technology innovation are context-specific. One approach will not fit all.

And, finally, in order for technologies to make a real difference on the ground, we need to advance scientific research, as well as

regulatory systems, public education initiatives, and the international activities that create and maintain the enabling environment for technology application.

My written testimony lists several species-specific examples that support these points. I am just going to mention two here.

Opportunities for reducing the spread and impact of cheatgrass in western rangelands are being improved through a combination of surveillance and mapping technologies, as well as biocontrol, chemical control, and genetic engineering, for example, to reduce herbicide resistance.

In eastern wetlands, opportunities for controlling, perhaps even some day eradicating, nutria are being improved through advancements in snare, trap, and attractant technologies, as well as the use of artificial resting platforms, camera traps, DNA sampling, detector dogs, and what are referred to as Judas nutria, nutria that are captured, sterilized, then radio-collared, re-released, and followed in the hope that they will lead trackers to other nutria.

This is a particularly timely hearing for NISC. As already mentioned, we recently cohosted an Innovation Summit on invasive species, the first-ever meeting to address technology innovation for invasive species from scientific, regulatory, and social perspectives. More than 300 people participated, including invasive species scientists and managers, technology innovators, experts in technology innovation, and technology grant makers.

A report that summarizes the key points made by the participants and identifies opportunities for Federal leadership on technology innovation explicitly in the invasive species context is anticipated at the end of the month.

In conclusion, I would like to underscore the fact that investments in technology innovation and application can represent a long-term cost savings compared to the approaches currently available to address invasive species challenges. These investments can have substantial payoffs, potentially in the millions of dollars for a single species.

Mr. Chairman, Ranking Member, members of the Committee, thank you for the opportunity to testify. I am happy to address the Committee's questions regarding NISC's role in advancing technology innovation so that we can change the conversation from "we can't" to "We can do this. Let's get it done."

[The prepared statement of Ms. Reaser follows:]

STATEMENT OF JAMIE K. REASER
EXECUTIVE DIRECTOR
NATIONAL INVASIVE SPECIES COUNCIL
BEFORE THE
SENATE COMMITTEE ON ENVIRONMENT & PUBLIC WORKS
REGARDING INNOVATIONS IN FIGHTING INVASIVE SPECIES AND CONSERVING WILDLIFE

March 15, 2017

Mr. Chairman and members of the Committee, thank you for the opportunity to appear before you at this hearing on innovations in fighting invasive species and conserving wildlife. This is a particularly timely hearing for the National Invasive Species Council (NISC). We recently co-hosted the first annual Innovation Summit on invasive species, a major gathering of leading scientists, innovators, and entrepreneurs to solve seemingly intractable problems – problems that leave us vulnerable to the adverse impacts of invasive species.

National Invasive Species Council (NISC) Leadership

The Federal Government defines invasive species to mean, with regard to a particular ecosystem, a non-native organism whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human, animal, or plant health.

It is the policy of the United States to prevent the introduction, establishment, and spread of invasive species, as well as to eradicate and control populations of invasive species that are established. Invasive species pose threats to prosperity, security, and quality of life. They have negative impacts on the environment and natural resources; agriculture and food production systems; water resources; human, animal, and plant health; infrastructure, the economy, energy, cultural resources, and military readiness. Every year, invasive species cost the United States an estimated $120 billion in economic losses and management expenditures.

Across the Federal government, agencies are focused on combatting invasive species. This includes efforts to prevent the introduction, establishment, and spread of invasive species, as well as to eradicate and control populations of invasive species that are established. The NISC is an interdepartmental body charged with providing the vision and leadership necessary to coordinate, sustain, and expand federal efforts to safeguard the interests of the U.S. through the prevention, eradication, and control of invasive species, and through the restoration of ecosystems and other assets impacted by invasive species. NISC was established in 1999 under Executive Order 13112. At that time, NISC comprised the senior-most leaders of eight Federal Departments. In December 2016, NISC and its duties were expanded under Executive Order 13751.

NISC is co-chaired by the Secretaries of the Interior, Agriculture, and Commerce. Other Federal member agencies include the Secretaries of State, Treasury, Defense, Health and Human Services, Transportation, and Homeland Security; the Administrators of the National Aeronautics and Space Administration, Environmental Protection Agency, U.S. Agency for

International Development, the U.S. Trade Representative; and, in the Executive Office of the President, the Directors of the Office of Science and Technology Policy, Council on Environmental Quality, and the Office of Management and Budget.

A small staff of experts in science, technology, policy, program management, and interdepartmental coordination is responsible for carrying out the day-to-day duties of NISC, including coordinating the development and implementation of the NISC Management Plan. The Department of the Interior administers this Secretariat.

NISC provides high-level policy and planning on invasive species, from a whole of government perspective. This involves providing institutional leadership and priority setting, facilitating effective coordination and cost-efficiency within the Federal Government and with non-federal partners, raising awareness of the invasive species issue and motivating high-impact action, removing barriers to getting the job done effectively on the ground, assessing and strengthening federal capacities as needed to meet the Council's duties, and, most importantly for this hearing, fostering innovation.

The remainder of my comments will focus on NISC's work to foster innovation, with particular emphasis on initiatives to advance technological innovation.

Technology Innovation: An Invasive Species Game Changer

The invasive species issue has been plagued by a misconception, a belief that the issue is too complex, too difficult, too costly to overcome. Frequently, the resulting attitude has been, "Why bother?" Investments in technology innovation can be game changing. They are demonstrating that seemingly insurmountable challenges can be overcome with substantial return on investment. They are helping us change the conversation from "can't" to "can" and "let's get it done, now!"

I would like to make five general points about technology innovation in the context of the invasive species issue and then focus on relevant NISC directives, priority actions, and outputs.

First, in order to be effective, **advancements in technology innovation need not require substantial investments in time or money.** There are numerous "low tech" innovations being made with relatively rapid, cost-efficient outputs. For example, intellectual advancements in risk analysis and horizon scanning approaches improves our capacities to target high risk invasive species and invasion pathways. Websites and smartphone applications are enabling invasive species managers and the public to access the information necessary for the early detection of and rapid response to invasive species (e.g. https://www.eddmaps.org/). Detector ("sniffer") dogs are being trained to locate a wide range of invasive species – from zebra mussels to Burmese pythons – in order to facilitate eradication and control opportunities. Small modifications in gun design are enabling the broadcasting of herbicides and toxic baits into environments that are difficult to access.

Secondly, **many of the technologies that could help us prevent, eradicate, or control invasive species already exist, but they were developed for other applications.** The reapplication of

existing technologies is cost-effective and facilitates the emergence of new markets for the private sector. Technology innovation is a catalyst for public-private partnership. For example, Whooshh Innovations has been developing soft, flexible air-filled tubes that use gentle pressure variances to move objects – initially large volumes of fruit. With support from the Department of Energy, they are now using the system to cost-effectively photograph, sort, and move fish upstream. Although the initial target of the work was to transfer native fish (e.g. salmon or trout) over dams and other barriers, further adaptations to the system are being explored to enable the automated detection and extraction of invasive carp, lampreys, and other harmful aquatic species.

Third, **opportunities are emerging to assemble a comprehensive toolbox** to address some of the most imperative invasive species challenges. For example, satellites, drones, automated trapping systems, and DNA sampling techniques are being combined to develop predictive models to better understand the transmission of human disease via invasive mosquitoes.

Fourth, **best practices for technology application are context specific**, one approach will not fit all scenarios (Table 1). Considerations for developing "fit to purpose" approaches need to explore such variables as the biology of the target species, time of year/day for maximizing effectiveness, ecological and socio-cultural context, legal and institutional frameworks and, of course, budget constraints and timeliness.

Table 1. Examples of technologies being applied and/or considered for application to some of worst invasive species challenges in the United States.

Selected Species	**Examples of Technology Applications**
Asian carp	eDNA, barriers (e.g., underwater electroshock barriers, walls of carbon dioxide bubbles, fencing, locks), species-specific toxicants (carpicide), genetic engineering (e.g. to influence hybridization, sex determination, sterilization – research/conceptualization in progress), and overharvest
Cheatgrass	Remote sensing, video mapping linked to global positioning systems (GPS) and geographic information systems (GIS), biocontrol (options being explored), herbicides, genetic engineering (e.g. reducing herbicide resistance)
Chestnut blight	Genetic engineering (blight resistance), biocontrol (exploring introduction of a "helper virus")
Cogongrass	Mapping technologies, herbicides, biocontrol
Fire ant	Mapping technologies, baits, toxicants, large-scale hot water applications, biocontrol
Leafy spurge	Mapping technologies, herbicides, biocontrol
New Zealand mudsnail	Toxicants, temperature treatments, dessicants,

	biocontrol (predatory trematode), genetic engineering (theoretical)
Nutria	Snares, traps, attractants, "Judas nutria" (sterilization, radio tracking), artificial resting platforms, camera trapping, DNA sampling, detector dogs, genetic engineering (theoretical)
Purple loosestrife	Mapping technologies, herbicides, biocontrol (e.g. *Galerucella spp.),* site modification (e.g. dredging)
West Nile virus	Mapping technologies, predictive analytics and risk analyses tools, automated sampling, genetic engineering of mosquitoes (e.g. sex determination, inability to carry virus), vaccines
Zebra mussel	eDNA, watercraft inspection/decontamination, antifouling products, screening, heat treatment, chemical oxidation, sealing contaminated infrastructure, pulse acoustics, magnetism, UV light, genetic engineering (theoretical)

Finally, in order for technologies to make a real difference on the ground, **focus need not only be on scientific research, but also on the advancement of regulatory systems, social acceptance of technologies and international cooperation** that create and maintain the enabling environment for technology application. This is particularly true with regard to some of the technologies that hold the greatest potential to make a significant impact on a large scale. For example, drones are in use for everything from surveillance to injecting toxins, the development and release of biocontrol agents, and the use of genetic-based tools to eradicate populations of invasive species.

The Federal Government has numerous roles to play in advancing technologies for the prevention, eradication, and control of invasive species. Examples include:

- communicating the need for technology innovation to address pressing invasive species challenges;
- catalyzing and incentivizing technology innovation and re-application;
- enabling innovators to reach proof of concept and put their ideas to work on meaningful scales, potentially producing new industries and jobs in the process;
- creating, advancing, and maintaining the intellectual property rights framework necessary for technology development and application; and
- applying technologies to prevent entry, detect and respond to potential invasive species before they have a chance to cause harm, and to eradicate and control those invasive species that are already established.

Technology application not only solves problems but also can provide a return on investment, creating an incentive for new investments and breakthroughs.

Current Priorities

The current priorities for NISC's work to advance technology innovation are set forth in Executive Order 13751 and the *2016-2018 NISC Management Plan.* Section 3 of the Executive Order states:

(e) To the extent practicable, Federal agencies shall also expand the use of new and existing technologies and practices; develop, share, and utilize similar metrics and standards, methodologies, and databases and, where relevant, platforms for monitoring invasive species; and, facilitate the interoperability of information systems, open data, data analytics, predictive modeling, and data reporting necessary to inform timely, science-based decision making.

In Section 4, technology innovation is recognized as an emerging priority for the Council:

(c) Federal agencies shall.....promoting open data and data analytics; harnessing technological advances in remote sensing technologies, molecular tools, cloud computing, and predictive analytics; and using tools such as challenge prizes, citizen science, and crowdsourcing.

Section 6 states that the Council shall provide national leadership regarding invasive species and shall, among other things:

(e) support and encourage the development of new technologies and practices, and promote the use of existing technologies and practices, to prevent, eradicate, and control invasive species, including those that are vectors, reservoirs, and causative agents of disease.

Section 7, which directs NISC to publish a National Invasive Species Council Management Plan every three years, states that the Management Plan shall include, among other things, recommendations to:

(6) foster scientific, technical, and programmatic innovation.

The *2016-2018 NISC Management Plan*, which pre-dated the revision of the original Executive Order by six months, includes a goal for the Council to:

Foster the scientific, technical, and programmatic innovation necessary to enable Federal agencies and their partners to prevent, eradicate, and/or control invasive species, as well as recover species and restore habitats and other assets in a timely and cost-effective manner with negligible impacts to human and environmental health.

The four priority actions to support implementation of this goal in the context of technology innovation are to:

1) create a mechanism for fostering the development, adoption, and sharing of the decision support tools that will enable NISC member Department/Agencies to more effectively implement the duties set forth in E.O. 13112, NISC Management Plans, and other guidance documents;

2) work with scientific and technical institutions, organize and co-host an Innovation Summit to

(a) promote scientific, technical, and technological advances that can facilitate invasive species prevention, eradication, and control, and

(b) identify priority needs for further advances in science and technology that can provide solutions to some of the worst invasive species challenges in the U.S. and elsewhere;

3) conduct an assessment of the potential ecological, socio-economic, and political benefits and costs of gene editing technology in the context of invasive species prevention, eradication, and control; and

4) based on the outputs of the previous action, develop guidance for the potential ecological, socio-economic, and political benefits and costs of gene editing technology in the context of invasive species prevention, eradication, and control; and

The Innovation Summit: A Break Through

I want to highlight the work that has already been accomplished in the implementation of the third action – organizing an Innovation Summit to advance the prevention, eradication, and control of invasive species. The Innovation Summit was held on December 5, 2016 at the Smithsonian Institution with funding provided by the Laura and John Arnold Foundation. The partner organizations that co-hosted the event included the NISC Secretariat, Smithsonian Institution, Arnold Foundation, Island Conservation, Conservation X Labs and the ANSTF. More than 300 people participated in person or via webcast. Participants included invasive species scientists and managers, technology innovators, experts in technology regulation, and technology grantmakers.

The Innovation Summit was the first ever event to explicitly focus on technology innovation for invasive species from scientific, regulatory, and social perspectives. Through presentations and panel discussions, experts representing a wide range of disciplines reviewed grand challenges in invasive species management (e.g. from invasive grasses that impact rangelands to nutria that threaten infrastructure), new approaches and applied technologies to address these invasive species challenges, mechanisms for incentivizing innovation, the need to create the enabling environment for the technology application (including regulatory, legal, and social barriers), how to best attract technology innovators, and recommendations for moving forward.

The Summit agenda, speaker bios, abstracts, and presentation recordings are available on the NISC website at http://www.doi.gov/invasivespecies/innovation. A report of the Summit is in progress. We anticipate that it will be released by the end of the month, at which time it will also become available on the NISC website.

The presentations and discussions at the Summit did highlight a variety of opportunities for advancing federal leadership in technology innovation for invasive species. Examples include:

- communicating the "grand challenges" in invasive species prevention, eradication, and control to the entrepreneurial community across a wide range of sectors. Those with problems need to become far more visible to those who are highly motivated to innovate solutions;

- incentivizing technology development by the private sector through competitions, prizes, or other initiatives that inspire entrepreneurs to tackle the most pressing invasive species challenges;
- promoting the availability of federal technology grant programs to invasive species scientists and managers. Summit participants included representatives of the Small Business Administration's Small Business Innovation Research program, the Defense Department's Defense Advanced Research Projects Agency, the National Science Foundation's I-Core Program, and the Office of the Director of National Intelligence's Intelligence Advanced Research Projects Activity for the rapid development and commercialization of frontier science and technologies;
- exploring mechanisms to advance regulatory frameworks in a timely manner. Technological advancements – particularly those related to automation and gene-based technologies – are now outpacing the ability of regulatory systems to effectively regulate these technologies;
- fostering public education/outreach initiatives in order to address social concerns about technology development and application in the invasive species context; and
- cultivating an "innovation culture" within and outside the federal government. A wide range of opportunities and options exist to facilitate highly productive and inspirational interactions that result in innovating thinking and outputs. These could include and be built into future Innovation Summits.

Conclusion

Transformative solutions drawing on advances in technological innovation exist and can be game changers in addressing invasive species. Federal agencies play a key leveraging role in working with partners to identify challenges and opportunities, expand investment, and reduce barriers to the development and application of possible solutions. These technology innovations and their application can represent a long-term cost-savings compared to existing expensive practices. Prioritizing technology innovation can have substantial payoffs – potentially saving millions of dollars in costs posed by a single invasive species.

Mr. Chairman, thank you for the opportunity to testify. I am happy to address the Committee's questions regarding NISC's role in advancing the innovation culture necessary to change the conversation from "We can't" to "We *can* do this…"

Senate Environment and Public Works Committee
Hearing entitled, "Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation"
March 15, 2017
Questions for the Record for Dr. Jamie K. Reaser

Chairman Barrasso:

1. Dr. Reaser, The National Invasive Species Management Plan for 2016-2018, states, "there is a common belief that, once established, it is no longer logistically or financially feasible to eradicate or control populations of invasive species." Do you believe this line of reasoning limits innovative thinking and advancements that could potentially solve invasive species problems?

Response: Although policy makers, land managers, and the public are increasingly aware of the invasive species issue, the commitment to problem resolution remains well below that needed to address the problem. Unfortunately, invasive species challenges are frequently considered too complex and difficult to overcome, which undermines innovation.

It is clear, nevertheless, that investments in technology innovation are rapidly advancing our ability to prevent, eradicate, and control invasive species. There is renewed hope that we can overcome the "grand invasive species challenges" that have thus far seemed insurmountable. The application of repurposed and emerging technologies can provide substantial returns on investment, as well as foster further innovative thinking and advancements.

The message that "we can do this" was featured in my opening and closing remarks at the Innovation Summit. The presentation recordings are available on the NISC website: https://www.doi.gov/invasivespecies/innovation-summit-project.

2. Dr. Reaser, Mr. Nesvik testified that watercraft inspection stations are one of the most effective ways to stop the spread of aquatic invasive mussels and protect neighboring and distant bodies of water. Some of these inspection stations are supported by the Corps of Engineers through Water Resources Development Act authorizations. The Bureau of Reclamation also supports some inspection stations. In the past, these resources have been slow to be distributed, impeding States' abilities to combat the spread of quagga and zebra mussels. Considering the rate at which these species can propagate, coupled with the national environmental and economic havoc they inflict, it is critical we move fast.

As the National Invasive Species Council works with multiple agencies to implement the recommendations in the report *Safeguarding America's Lands and Waters from Invasive Species: A National Framework for Early Detection and Rapid Response*, how do we ensure agencies do not get bogged down in bureaucracy and are agile enough to respond quickly to threats?

Response: In order to be effective, early detection and rapid response (EDRR) programs for invasive species must be built on a coordinated framework that enables relevant agencies to: a) anticipate the need for response, b) detect non-native species early in the entry and/or establishment process, and c) promptly deploy technical, financial, and staff resources.

With a view toward creating such a framework, NISC has already integrated the recommendations of the *Safeguarding America's Lands and Waters from Invasive Species* report into the *2016-2018 Management Plan* and supported the Council duty set forth in Executive Order 13751 to "advance national incident response, data collection, and reporting capacities that build on existing frameworks and programs and strengthen early detection of and rapid response to invasive species, including those that are vectors, reservoirs, and causative agents of disease."

The Council staff are now undertaking and facilitating several assessments of federal capacities to implement EDRR and extracting lessons learned from models of other national incident response programs (e.g. wildfire, natural hazards, disease outbreaks). Particular attention is being paid to identifying the mechanisms that will help NISC avoid bureaucratic shortfalls. Examples include: a) proactively identifying and, as needed, clarifying relevant jurisdictions and authorities; b) establishing interagency agreements for coordination among relevant government agencies at all levels, with the flexibility to include non-governmental partners; c) employing agile funding mechanisms (aka rapid response funds); and d) establishing a communications network that enables easy access to and the rapid sharing of the information needed for timely decision making (e.g. species identification, alerts of invasive species intercepts, decision support tools).

The NISC Secretariat is currently supporting projects in Montana (mussels) and Wyoming (medusahead) in order to garner lessons learned from their state-level EDRR initiatives. The information synthesized from these projects will contribute to the development of a blueprint for a national EDRR program for invasive species.

Senator Harris:

3. According to a report by the University of California, Riverside Center for Invasive Species Research, it is estimated that invasive species cost the United States $138 billion per year in maintenance and mitigation efforts. In California alone, invasive pests cost the state $3 billion annually. As you know, California has a diverse need to control invasive pests from both conservation lands and, just as importantly, the agricultural industry. For example, California citrus farmers have assets worth up to $2.5 billion in fruits they produce and ship all over the world. However, the Asian citrus psyllid, which originated from Southeast Asia, has recently threatened to compromise this industry. Florida has had similar issues protecting their agricultural commodities from this species. What specific plans does your council and its partners have to prevent invasive species from entering at our country's ports of entry?

Response: Preventing the entry of invasive species at U.S. ports of entry is a responsibility shared by multiple agencies. Recognizing that prevention is typically the most cost-effective approach to minimizing invasive species impacts, the Council supported the duty set forth in

Executive Order 13751 to "publish an assessment by 2020 that identifies the most pressing scientific, technical, and programmatic coordination challenges to the Federal Government's capacity to prevent the introduction of invasive species, and that incorporate recommendations and priority actions to overcome these challenges into the National Invasive Species Council Management Plan, as appropriate." Relevant actions currently being taken by the Department of Homeland Security (DHS)/Customs and Border Protection (CBP), Department of Health and Human Services (HHS)/Centers for Disease Control (CDC), Department of the Interior (DOI)/U.S. Fish and Wildlife Service (USFWS) and U.S. Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) are summarized below:

DHS/CBP: [Awaiting from CBP.] Each year, CBP agriculture specialists intercept thousands of "actionable pests" – those identified through scientific risk assessment and study as being dangerous to the health and safety of U.S. agricultural resources. CBP's inspection and detection activities are conducted by a cadre of highly-trained CBP agriculture specialists (CBPAS). CBPAS use their science-based education, background, and expertise to apply a wide range of Federal, state, and local laws and agency regulations in the process of determining the admissibility of agriculture commodities while, at the same time, preventing the introduction of harmful pests, diseases, and potential agro-terrorism into the United States.

In both the travel and trade environments, and across all modes, CBP's multilayered approach to agriculture security necessitates a comprehensive awareness of threats, substantial information sharing and coordination, and advanced detection capabilities. To enhance agriculture targeting, CBP developed the framework for a National Agriculture Cargo Targeting Unit (NACTU) at the National Targeting Center (NTC). This new agriculture unit focuses solely on agriculture threats to identify potential and repeat violators that may import shipments with pests, prohibited products, contaminants, or smuggled products in all cargo pathways (rail, air, sea, land, and Express Carrier Pathway). In addition to targeting capabilities, CBP deploys a cadre of specialized technology, and other resources to screen passengers and cargo to prevent the introduction of harmful plant pests and foreign animal diseases in the United States. CBP is also using technology to transform business processes. CBP is expanding the Enforcement Link Mobile Operations – Cargo (ELMOc) program by deploying mobile devices to CBPAS in all environments (air, land and sea border ports). CBPAS will have remote access available at their workstation, allowing them to close out exams without having to return to ports (real-time release). This is a mobile solution to better facilitate mission critical operations and address the needs of CBPAS to perform inspections of cargo without being bound to a physical location. CBP has implemented system automation to properly capture the Customs and Border Protection Agriculture workflow and integrate CBP systems with U.S. Department of Agriculture's (USDA) reporting systems to provide data required under the existing Memorandum of Agreement between both agencies. With the work completed to date, commodity data, pest interception, and emergency action notifications can be captured within CBP systems and available in real time to USDA systems. Prior to this, CBP Agriculture specialists had to use both CBP and USDA database to document their findings. This innovation has provided CBP Agriculture specialists a leverage to spend more time in inspection and regulation instead of lengthy and redundant data entry process.

HHS/CDC: The CDC oversees vector-borne and other infectious disease control activities as they impact human health. Increasingly, the interface between human and animal health has been recognized (under the rubric of 'One Health'), particularly for human illnesses that have intermediate animal hosts, and for illnesses that may be transmitted by insect vectors. CDC uses an innovative One Health approach by working with physicians, ecologists, and veterinarians to monitor and control public health threats. It does this by learning about how diseases spread among people, animals, and the environment. CDC monitors human and animal disease outbreaks associated with environmental conditions such as harmful algal blooms (OHHABs https://www.cdc.gov/habs/ohhabs.html), and manages general disease surveillance and detection systems through the CDC Division of Health Informatics and Surveillance (https://www.cdc.gov/surveillancepractice/index.html).

In addition, CDC has 20 quarantine stations located at ports of entry and land border crossings as part of a comprehensive quarantine system that serves to limit the introduction of infectious diseases into the United States and to prevent their spread; see: Protecting America's Health at U.S. Ports of Entry. A recently established surveillance system known as MosquitoNET collects state reports of *Aedes aegypti* and *Aedes albopictus* mosquito vectors of disease as well as insecticide resistance testing.

DOI/USFWS: The USFWS is authorized to designate species as injurious wildlife under title 18 of the Lacey Act. A listing as injurious prohibits the importation of that species. Relying on this authority, the Service has taken action to prohibit the importation of 621 injurious species (although insects, including Asian citrus psyllids, cannot be listed under title 18). In addition, the enforcement of federal laws and regulations related to injurious species is a priority for USFWS's Office of Law Enforcement.

USDA/APHIS: U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) protects our Nation's agriculture and natural resources from invasive pests and diseases. At the core of APHIS' safeguarding mission is its pest exclusion system—a continuum of strategies and activities that work together to minimize the plant health risks that come with agricultural imports, international travel, and the smuggling of prohibited agricultural products. This system of overlapping safeguards begins offshore, continues through U.S. ports of entry, and extends across the Nation with our exotic pest and disease surveillance and management programs.

If harmful pests and diseases enter the United States, APHIS is prepared to detect them early and respond rapidly and effectively. We work closely with Federal, State, Tribal, and industry partners to reduce damage to agriculture and natural resources and, when possible, eradicate foreign plant pests and diseases from our country. APHIS also works with countries around the globe to promote a safe, fair, and predictable trade system that helps prevent the spread of invasive pests and diseases. This collaborative effort, is built on international and regional harmonized, science-based plant health measures that not only reduce pest risks, but also helps to create a level playing field for U.S. products abroad. We also help U.S. exporters meet the plant health requirements of importing countries by certifying the health of U.S. exports, which ensures the product meets the importing countries' entry requirements.

4. What federal programs has your Council been able to leverage to relieve state, local, and industry partners to deal with the environmental and economic impacts of invasive species? As the budget discussions begin, what would be the repercussions if funding levels for these programs decreased?

Response: Investments that the Federal Government makes in the prevention, eradication, and control invasive species benefit state and local communities and the nation as a whole. The Federal government serves as a partner with local, state, territorial, and tribal governments, as well as the private sector to achieve the best results and solutions for each individual scenario.

In the context of innovation, there are two particularly important ways in which the Federal Government can assist state and local governments, as well as the private sector, regarding the economic impacts of invasive species:

1. *Innovative partnerships*: Programs that bring federal, state, local, tribal and private sector representatives together help establish and implement plans for the prevention, eradication, and control of invasive species. These efforts play an integral role in raising awareness and galvanizing support for concerted and coordinated actions to protect states and communities from the impacts of aquatic invasive species, such as quagga and zebra mussels.

2. *Advancing technology innovation*: The actions that the Federal Government takes to improve the "invasive species toolkit" through advancements in regulatory frameworks, scientific and technological solutions, and supporting markets for technology applications provide benefits at all levels of government and to the private sector. More effective and cost-efficient tools are needed to prevent the introduction and mitigate the impacts of invasive species.

Senator BARRASSO. Dr. Reaser, thank you very much for joining us, for sharing your testimony.

I would like to next turn to David Ullrich, who is Chairman of the Great Lakes Fishery Commission.

Thanks for joining us today, sir.

STATEMENT OF DAVID ULLRICH, CHAIRMAN, GREAT LAKES FISHERY COMMISSION, ANN ARBOR, MICHIGAN

Mr. ULLRICH. Thank you very much and good morning, Chairman Barrasso, Ranking Member Carper, and all members of the Committee today. My name is David Ullrich, as the Chairman said. The Great Lakes Fishery Commission has been actively engaged in the management of sea lamprey for many, many years.

The Great Lakes and St. Lawrence region is an economic powerhouse for the United States and Canada. The Fishery alone generates roughly $7 billion in economic activity annually for the Great Lakes. Unfortunately, the Great Lakes are under assault from over 180 different types of invasive species that inflict more than $5.4 billion in annual damages to our resources.

The history of aquatic invasions has shown that people are left with few options to control a species once they are introduced and spread. Innovative solutions, which is why we are here today, can make a big difference. The highly successful sea lamprey program provides an excellent example.

As you can see from the picture, they are not pretty. They are gruesome, in fact, and they attach to fish with their suction cup mouths. They dig their teeth into the sides for a grip, and then their tongues are used to rasp in through the scales and the skin with their sharp tongue, and then they inject an anticoagulant in and then they remove the body fluids from the fish.

Senator CARPER. Mr. Ullrich.

Mr. ULLRICH. Yes, sir.

Senator CARPER. What is the circumference or the diameter of the photo?

Mr. ULLRICH. Oh, I don't know, they would be about a couple inches, something like that. Not real big. They are long and skinny, but they attach right on the side and then do their work.

They enter the Great Lakes through the shipping canals and, having no predators and lots of food, inflicted horrendous damage on the fishery and the hapless fishers.

By the way, when you join the Fishery Commission, you are required to have one put on your arm for a little while and see if you are tough enough to be on the Commission.

[Laughter.]

Senator BARRASSO. I volunteer Senator Carper as a new member of the Commission.

[Laughter.]

Mr. ULLRICH. Do we have a sea lamprey?

Senator CARPER. We did that in my fraternity initiation.

Mr. ULLRICH. OK. Very good.

[Laughter.]

Senator CARPER. Second to waterboarding.

Mr. ULLRICH. OK.

Over the years, we have reduced the lamprey populations by 90 percent in most of the Great Lakes. In fact, we are at a 30-year low in Lake Huron, a 20-year low in Lake Michigan, and near targets in two of the other three lakes.

As the chart next to me, now the chart, will show you, we have gone from losing 100 million pounds of fish per year to only 10 million pounds. That is still too many, but we have made tremendous progress.

The $7 billion Great Lakes Fishery would not exist were it not for the sea lamprey control program. The Commission and its partners have achieved this remarkable level of success through innovation, persistence, technology, and sustained binational commitment. We work hand-in-glove with the Canadians on this.

The work started in the 1930's and 1940's on this, and the first breakthrough was in 1957, where one chemical, a lampricide, was found out of 10,000 different chemicals that really got in and destroyed the sea lampreys. We integrated barriers into the work in 1970 to block their migration and spawning habits. We continue to use traps and innovate these traps, and also have developed innovative techniques in larger bodies of water on the application of the lampricide.

Several approaches are emerging that are particularly promising, and this is what is especially important for the future, and that is the sea lamprey genome has been sequenced. This achievement will allow science to customize control techniques and exploit the sea lamprey's life cycle. We have also detected pheromones, which sea lampreys use as odors to detect in minute concentrations what directions they ought to go.

We are concerned about dam removals. Although it is a good thing for fish passage, it is a bad thing for lampreys; it opens up more areas for spawning. So we are trying to build some smart fish passage systems.

It would not be the successful approach it is today without innovative governance arrangements. The Fishery Commission is accountable for making this happen with Fish and Wildlife and Department of Fisheries and Oceans. We know that a single invasive species can cause huge damage. Prevention is the key and we need to continue to work to find more innovative approaches in the future.

Thank you very much for allowing me to testify today.

[The prepared statement of Mr. Ullrich follows:]

INNOVATIVE SOLUTIONS IN THE CONTROL OF INVASIVE SPECIES: LESSONS FROM THE SEA LAMPREY

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Committee on Environment and Public Works
U.S. Senate
Honorable John Barrasso, Chairman
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INVASIVE SPECIES AND THE DESTRUCTION THEY BRING

Chairman Barrasso and Mr. Carper, thank you for inviting me to appear before this committee to discuss innovative solutions to invasive species. My name is David Ullrich. I am the chair of the Canada-U.S. Great Lakes Fishery Commission. The Commission knows a great deal about invasive species. The commission was established in 1954 by the Canadian and U.S. Convention on Great Lakes Fisheries primarily as a response to one of the most injurious invaders to ever enter the Great Lakes system: the sea lamprey. I am also the executive director of the Great Lakes and St. Lawrence Cities Initiative, which coordinates the actions of more than 120 Canadian and U.S. mayors to advance the protection and restoration of the resources. Both the commission and the initiative are highly involved in invasive species prevention and management because of the severe economic and ecological damage such species cause.

The Great Lakes and St. Lawrence River Region is an economic powerhouse for the United States and Canada. The region contains 84% of the North American's surface freshwater and is home to 100 million Canadians and Americans, 40 million of whom rely on the resource for drinking water. The region is the third largest economy in the world with $5.8 trillion annually in economic activity.[1] The fishery alone generates more than $7 billion each year[2] and the system is a vibrant transportation corridor that moves goods in and out of the North American heartland. Moreover, the Great Lakes and the St. Lawrence River are unrivaled in natural beauty, which enhances property values and the quality of life, and attracts millions of tourists.

Unfortunately, the Great Lakes are under assault from invasive species. Invasive species are non-native animals and plants, both aquatic and terrestrial, that enter new environments, become established, and spread. Today, the lakes harbor more than 185 non-native species.[3] Invasive species generally enter new ecosystems accidentally, find the new environments to be accommodating for reproduction, have ample food, and have few or no predators that keep them in check. Invaders have entered the Great Lakes through the discharge of ship ballast water, the trade of live organisms for food and pets, the release of live baitfish, canals and waterways, and the movement of pleasure crafts between watersheds.

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* This testimony was written by Marc Gaden and David Ullrich with assistance from Michael Siefkes, Cory Brant, Robert Lambe, and Jill Wingfield.

Most affected by invasive species are sport, commercial and tribal fishers; water treatment and power generation plants; manufacturing; and tourism. Collectively, hundreds of thousands of people are employed in these industries. Although quantification of the costs of invasive species is difficult, what we do know is sobering. Worldwide, invasive species cause more than $1.4 trillion in damage annually; damage costs range from $14 to $137 billion annually in the U.S., depending on species considered and assumptions.[4] In the United States, invasive species costs the sportfishing industry more than $5 billion annually and zebra and quagga mussels cause a conservative $1 billion per year in damage mitigation.[5] Invasive species inflict $5.4 billion in annual damages to the Great Lakes alone.[6] Aptly, Ricciardi et al, in a 2011 study,[7] likened biological invasions to natural disasters like floods, earthquakes, and disease epidemics (and, thus, they argued, should be treated with the same response and preparedness). Ricciardi adds that invasive species inflict a cost on an order of magnitude higher than natural disasters.[8] At least 40% of the species on the threatened or endangered list are on the list because of invasive species.[9]

The history of aquatic invasions has shown that people are left with few options to control a species once the species enters an ecosystem and spreads. Physical removal of terrestrial invasive species is cumbersome and disruptive. Control of aquatic invaders is difficult given the paucity of selective control techniques. Thus, prevention is paramount. Nevertheless, in cases where invasive species are present or looming, innovative solutions using technology and ingenuity can make a difference. The highly successful sea lamprey control program provides us with positive examples.

SEA LAMPREY CONTROL IN THE GREAT LAKES: INNOVATION AND SUCCESS

Sea lampreys are primitive eel-like fishes native to the Atlantic Ocean (figure 1).[10] Sea lampreys attach to fish with their suction cup mouth then dig their teeth into flesh for grip (figure 2). Once securely attached, sea lampreys rasp through the fish's scales and skin with their sharp tongue. Sea lampreys feed on the fish's body fluids by secreting an enzyme that prevents blood from clotting, similar to how a leech feeds off its host (figure 3A and 3B).

The first recorded observation of a sea lamprey in the Great Lakes was in 1835 in Lake Ontario. Niagara Falls served as a natural barrier, confining sea lampreys to Lake Ontario and preventing them from entering the remaining four Great Lakes. However, in the late 1880s and early 1900s, improvements to the Welland Canal, which bypasses Niagara Falls and provides a shipping connection between lakes Ontario and Erie, allowed sea lampreys access to the rest of the Great Lakes. Within just a short time, sea lampreys spread throughout the system: into Lake Erie by 1921, lakes Michigan and Huron by 1936 and 1937, and Lake Superior by 1938.[11]

Sea lampreys were able to thrive once they invaded the Great Lakes because of the availability of excellent spawning and larval habitat, an abundance of host fish, a lack of predators, and their high reproductive potential—a single female can produce as many as 100,000 eggs.

In their native Atlantic Ocean, thanks to co-evolution with fish there, sea lampreys are parasites that typically do not kill their host. In the Great Lakes, where no such co-evolutionary link exists, sea lampreys act as predators, with each individual capable of killing up to 40 pounds of fish over its 12-18 month feeding period. Host fish in the Great Lakes are often unable to survive sea lamprey parasitism, either dying directly from an attack or from infections in the wound after an attack. Host fish that survive attacks often suffer from weight loss and a decline in health and condition.

Sea lampreys prey on most species of large Great Lakes fish such as lake trout, brown trout, lake sturgeon, whitefish, ciscos, burbot, walleye, catfish, and Pacific salmonids including Chinook and coho salmon and rainbow trout/steelhead. Sea lampreys wreaked staggering damage on the Great Lakes ecosystem. By the 1960s, harvest of lake trout, a keystone species, had fallen by 99% from the average catch of the 1930s

(figure 4). Basin wide, sea lampreys killed more than 100 million pounds of fish annually—a stunning amount of fish, especially when compared to the pre-invasion lake trout harvest of lake trout of 17 million pounds annually in the upper lakes.

Because of sea lamprey, the fishery that once sustained native fishers, fueled lucrative commercial operations, and attracted millions of anglers who simply enjoyed the outdoors, was devastated. Sea lampreys changed a way of life in the Great Lakes basin. The problem was so severe, the governments of Canada and the United States were largely motivated by the sea lamprey's devastation when they agreed to the 1954 Convention on Great Lakes Fisheries. The convention created my organization, the Great Lakes Fishery Commission, and, among other duties, gave it the responsibility to control the sea lamprey. I discuss the Commission as a unique governance arrangement below.

Since the convention began operating in 1956, the Commission has delivered a sea lamprey control program, in cooperation with the Department of Fisheries and Oceans Canada, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and state agencies. Through sound science and the use of innovative techniques, which I will describe below, the Commission has successfully reduced sea lamprey populations by 90% in most areas of the Great Lakes, which is consistent with the fishery management needs of our state, provincial, federal, and tribal partners. (Figure 5 illustrates sea lamprey abundance in each lake compared to pre-control abundance levels and target levels.)

This significant reduction in sea lamprey populations has reduced fish loss in the Great Lakes from approximately 100 million pounds annually to around 10 million pounds annually (figure 6). Although 10 million pounds is still a lot of fish, that amount is an order of magnitude lower than the 100 million pounds lost annually to lamprey in the past. The 90 million pounds saved from sea lamprey predation is 90 million pounds of fish that have the chance to grow old enough to reproduce, to be caught by humans, or to lead a natural life.

The $7 billion Great Lakes fishery would not exist as we know it today without sea lamprey control. Moreover, the states, the province of Ontario, the tribes, federal agencies, and the millions of people who depend on the fishery for jobs, recreation, and subsistence, also depend on sea lamprey control for that economic success. The fishery is also an important part of our history and culture.

How did the Commission and its partners achieve the remarkable level of sea lamprey control? Through innovation, persistence, technology, and a sustained, binational commitment.

The Beginnings: Understanding the Sea Lamprey

Sea lampreys bypassed Niagara Falls through the Welland canal around 1920 and by the middle part of that decade, fishers and scientists alike were beginning to realize they had severe problem on their hands. Walter Koelz and John Van Oosten, two pre-eminent scientists with the Bureau of Commercial Fisheries, noted the international nature of the problem and pleaded with commercial fishers as early as 1927 to report sea lamprey sightings so that the fishery managers would have a grasp of the degree of the problem. Their "wanted dead or alive posters," which they sent throughout the region, recognized the multi-jurisdictional nature of sea lamprey (they swim across borders with wild abandon after all) and also sounded the alarm about the impending invasion.

Early scientific literature catalogued the spread of sea lamprey and recorded the economic impact on the region's fishers. Just as state and federal biologists were observing more and more sea lamprey, commercial fishers were reporting dwindling catches. Worse still, the fish that were caught were so full of lamprey wounds they resembled Swiss cheese. While biologists and fishers were marking the spread and effects with growing trepidation, scientists were warning that control techniques were lacking.

The earliest innovations in sea lamprey control began in 1944 when state and federal conservation officials in northern Michigan constructed a mechanical weir on the Ocqueoc River to try and block sea lamprey migration. These officials later added electricity to the barrier to try to enhance its effectiveness. "Angry mobs" of local fishers used spears and pitchforks on the Ocqueoc to lend a hand. These early attempts at control, which also included work in other states like Wisconsin, and in Ontario, were only somewhat effective. The mechanical weirs still allowed considerable numbers of sea lampreys to pass and electrical barriers tended to short out, leaving the river unimpeded. Moreover, the electrical barriers killed large amounts of desirable fish. Sea lampreys continued to spread and as they did, it became apparent that the physical and mechanical approaches were not even slowing the invasion, let alone leading to control.

Researchers like Koelz, for years, had been stressing the need for better science so that sea lamprey control could be more targeted than crude electrical or mechanical weirs. As he said in 1927: "The problems that confront other fisheries confront the conservationist on the Great Lakes—we want to know more about the life histories of our species; we want adequate statistics; in short, we want to know everything about them . . . or no fish will remain for us to investigate." Koelz knew that a scientific understanding of the sea lamprey's life cycle would be the key to developing innovative control techniques. He was right.

With a growing amount of information about the pattern of invasion, Congressional interest led to the passage of legislation in 1946 authorizing funds for the Bureau of Commercial Fisheries to conduct the necessary scientific assessments that would lead to a detailed understanding of the sea lamprey life cycle. The State of Michigan supplemented those funds.

A biologist named Vernon Applegate was a pioneer in this era with his scientific work to study and publish the sea lamprey life history, with the purpose of discovering ways in which sea lamprey could be vulnerable.[12] The sea lamprey life cycle is unique, so it gave Applegate and his peers much to work with. Sea lampreys spend the first three to four years (some more than 10 years)[13] of their life living as larvae in stream beds. They are small and wormlike in this stage and they filter feed on detritus that drifts past. Applegate determined that larval sea lampreys inhabit approximately 500 Great Lakes tributaries throughout the basin. In the spring, after that larval phase, lampreys metamorphose into the lethal adult—they develop eyes, grow the suction cup mouth ringed with sharp teeth and a rasping tongue, and out-migrate to the open lake. Lampreys, during this metamorphic stage, are called "transformers." Once in the lake, they feed by attaching to fish with the suction cup mouth, bore a hole through the scales and skin, and consume blood and body fluids. Each lamprey will move from fish to fish while it feeds, usually destroying approximately forty pounds of fish. After about a year to eighteen months in the open lake, sea lampreys migrate into streams to spawn once and die. This deep understanding of the sea lamprey life cycle would (and continues to) result in many creative, innovative ideas for control.

Also in 1946, after several years of trying out different things to control sea lamprey, scientists and managers convened the Great Lakes Sea Lamprey Conference as a place to discuss the sea lamprey life history, present any ideas for how that life history could be exploited, and recommend control techniques. Innovation was the theme of the day. Many techniques, like mechanical weirs, electrical barriers, and out-migrating-larvae-removing sieves, were at one time considered innovative, but after field-testing and evaluation, were deemed ineffective. The group looked at everything from physical removal using hoop nets and commercial trawlers to dredging and concluded that a pesticide to kill larval sea lamprey would be the most viable solution.

One major hurdle to the use of a pesticide was the inopportune fact that nothing selective to sea lamprey existed. Any known pesticide that would be used, in other words, would not discriminate, potentially causing considerable loss to desired fish populations. Although Applegate was realistic enough to know that a pesticide was the best bet (most other techniques had already failed after all), in 1949, he nevertheless concluded that an integrated approach to sea lamprey, which would add barriers, traps, and electricity to the use of a selective pesticide when discovered, would be the best approach. Applegate's method was what later

would be called "integrated pest management;" this adaptive, innovative approach has prevailed throughout the history of the sea lamprey control program.

The Selective Lampricide

Efforts to discover a pesticide selective to sea lamprey began in 1950 when a graduate student from the University of Michigan—Philip Sawyer—began his experiments at an old Coast Guard station in Michigan that had been appropriated for scientific research. Sawyer, who was working through a fellowship with the Bureau of Commercial Fisheries, tested various compounds to determine what would kill lamprey and what would not harm fish. It was a tedious process. Over the next two years, Sawyer would zero in on a class of compounds that showed some promise, but a lack of funding for the field tests brought the search for a selective pesticide to a halt.

Only after Sawyer's dissertation demonstrated the clear potential of certain chemicals did the testing resume in 1953. Three years later, in early 1956, a technician named Cliff Kortman, working at the biological station, screened chemical number 5209 and simply wrote "special" in the results section of the report slip. It was special. The chemical was 3-trifluoromethyl-4-nitrophenol, or TFM, and it killed lamprey at low concentrations while not harming fish. Around this time, a second compound, called '5-dichloro-4'-nitrosalicylanilide, or niclosamide, was found to be a cost-effective way to supplement the use of TFM.[14] The two lampricides—deserving of that name, as they are pesticides selective to lamprey—would work in tandem.

Field tests in 1957 and 1958 with TFM (and derivatives of it) would demonstrate its effectiveness in the field. All told, during the seven or eight years of active search for a selective pesticide, scientists painstakingly screened nearly 10,000 compounds.[15] There was no shortage of determination to find the right lampricide.

The period 1958 through 1961 was a tense one for sea lamprey control agents. Although TFM proved effective in the laboratory and in limited field tests, its success on a management scale was not assured. When the data from the first large-scale round of steam treatments was published in 1965, the success was amazing: TFM had reduced sea lamprey population by 82% in the places where it was applied with minimal loss of non-target fish. Fishery managers exhaled.

Although the lampricide is selective to lamprey, the concentration at which it should be applied would prove to be critical. Some insecticides, for instance, remain selective even when 1000-times the amount needed to kill an insect is used. For lampricides, the selectivity ranges from only two to ten times the amount needed to kill a lamprey.[16] Thus, non-target fish like trout and walleye could be harmed if too much lampricide were to be used; not much room for error exists. During the early days of the lampricide program, the application was not precise, and fish kills were common. Sea lamprey control experts were at a loss as to why one treatment would work so well while another might not.

Unraveling the way in which lampricides work depended on two things: understanding how lampreys physically metabolize the chemical and understanding how stream chemistry itself affects the toxicity of lampricides. After much testing, scientists discovered that a stream's pH has an inverse relationship with TFM toxicity and that high stream alkalinity would exacerbate that pH/TFM relationship.[17] In other words, specific stream conditions, which could change rapidly from something as simple as a rain shower, would prove to be important—the lower the pH, the higher the toxicity of TFM and vice versa. Thus, to get the selectivity of TFM right, sea lamprey control crews would have to conduct on-site chemistry assays. That research into how lampricides work in lamprey and in streams, coupled with decades of data from thousands of stream treatments, led to vast improvements in the selective use of the lampricide, along with considerable cost savings. Currently, thanks to innovations in the manner in which lampricides are applied, non-target fish kills are extremely rare despite thousands of treatments.

Today, sixty years after the first lampricide field tests, lampricides remain the workhorse of the sea lamprey control program. Their discovery and ever-refined use through adaptive management came about because of an innovative culture that took root in the 1940s. That culture depended on science, encouraged creative thinking, valued innovation, learned from failure, and created the atmosphere to continually seek improvement. That innovative culture continues today as the Commission and its partners consider whether sea lampreys have developed a tolerance to lampricides and whether biological traits can be exploited. Such an understanding will lead to the development of the next generation of lampricides that are even more selective than the ones used today.

Barriers and Traps

As noted above, before the discovery and use of lampricides, fishery managers relied on barriers and weirs that were purpose-built for sea lamprey suppression, with mixed results. Barriers in general are quite effective at blocking sea lampreys as they migrate to reach their spawning grounds. Lampreys do not jump like trout and salmon, so even a small obstruction can be effective in limiting their range. The Great Lakes region contains thousands of dams and obstructions that block fish (including sea lamprey) migration. These dams were built for purposes other than sea lamprey control, such as for hydropower, flood management, pipeline protection, logging, industry, and the creation of private fishing holes.[18] Such barriers are not selective for sea lamprey but they do serve a useful purpose in the sea lamprey battle.

In 1971, the Commission revisited the idea of barriers as a specific control technique. The Commission reasoned that barriers built for sea lamprey control could be minimally intrusive, complementary to lampricides, and save considerable amounts of money.[19] With a sea lamprey barrier near the mouth of a stream, that stream would not require a lampricide treatment above the barrier.

To be effective in controlling lamprey, barriers do not have to be tall—a drop as short at 45 centimeters (about the height of a coffee table) would be sufficient.[20] Such short drop would present little obstacle for jumping fish, and other fish passage devices would accommodate non-jumping fish.

The new wave of better, more innovative barrier construction began in 1975. Eventually, approximately 75 sea lamprey barriers would be constructed between 1975 and 2017. Barriers remain extremely cost effective. For every $5 million spent on barriers, the Commission each year saves $500,000 in lampricide costs and $22 million worth of fish. Spread over the 50-year life span of a barrier, that $5 million investment saves more than $25 million in lampricide costs and $1.1 billion worth of fish.

Another benefit of barriers is the ability to integrate sea lamprey traps into the design or to simply place traps along the barrier face. Combining barriers and traps makes sense: sea lampreys, as they migrate upstream to spawn, are persistent, and when they hit an obstruction, they try to feel their way around it. In doing so, they might mistake an opening of a trap for passage around the barrier. Because a single female sea lamprey can produce up to 100,000 eggs, trapping spawners goes a long way to limit reproduction.

Barrier designs have evolved since the 1970s and continue to push the envelope of innovation. The Commission has experimented with a new generation of barriers equipped with electricity as a deterrent to migration, but the success has been limited. On the other hand, electricity, coupled with new trapping designs that apply lessons from eel ladders (lampreys swim like eels), have shown promise in helping to guide sea lampreys into traps. The Commission has experimented, also, with barriers that increase the velocity of a river to take advantage of a sea lamprey's poor swimming ability, but also with limited success. More promising are simple small structures, made from stop logs, that can be altered as river conditions change, or larger structures that can be raised (through inflation of air bladders) during the spawning run and lowered on the river bottom for the rest of the year.

Sterile-male-release and Granular Bayluscide

In 1937, a scientist by the name of Edward Knipling was the first to suggest that sterilization could be an effective technique to minimize or even eradicate insect populations.[21] Knipling's work would come to fruition in the mid-1950s with the successful use of sterilization to eradicate screwworms from the West Indies. From that point forward, sterilization has been an integral part of insect control worldwide.

In 1970, a biologist named Lee Hansen, working in the sea lamprey control program, suggested to the Commission that we could learn a lot from insect control; he proposed the Commission consider whether sterilized sea lampreys, released into streams, could reduce spawning without the use of barriers or lampricides. The risk of further loss of fish through the release of sterilized spawners was considered non-existent because once sea lampreys reach their spawning phase, they are physically incapable of feeding, as their digestive systems have shut down. At that point in their lives, sea lampreys have only reproduction in mind.

The Commission embraced Hansen's proposal in 1970 and launched a major investigation into whether sterilization could be an effective control method.[22] Between 1971 and 1991, the investigation led to the development of an effective sea lamprey sterilant (no such sterilant existed hitherto) after many compounds were tested. This search for a sterilant was certainly reminiscent of the massive search for a lampricide that took place in the 1950s. By 1991, the Commission also had identified sites where sterilization could be tested, conducted studies on the best practices for release of sterilized lampreys, determined that sterile males would be more effective than sterile females, and procured the equipment to sterilize sea lampreys. (On that last point, given the highly unique nature of the program, the equipment would be for a single user in the world and would have to be invented.) In 1991, the Commission launched sterile-male-release-technique (or SMRT) as a sea lamprey control method.

The SMRT works by putting enough sterilized male lampreys into a river to outnumber the fertile males. The sterile males successfully spawn with females, and lamprey eggs are fertilized. However, the sterilant used causes the eggs to produce non-viable larvae. Thus, both the males and the females think the spawning was successful when, in fact, it was not.

While the work was progressing to develop SMRT, major water quality improvements in the Great Lakes—thanks in part to the Great Lakes Water Quality Agreement and the Clean Water Act—had vastly improved fish habitat. The rebound in fisheries and fish health was astounding by the 1980s and 1990s.[23] But just as valuable fish like trout and salmon found the water quality improvements to be beneficial, so too did the sea lamprey. Nowhere was this more obvious than in the St. Marys River, an immense connecting channel between Lake Superior and Lake Huron that also happens to contain some of the best sea lamprey habitat in the entire Great Lakes basin. As the quality of the St. Marys River improved, sea lampreys spiked in that region and swam into Lakes Michigan and Huron like an invading army. At one point, the problem of lampreys from the St. Marys River was so severe, federal, state, tribal, and provincial fishery agencies stopped stocking fish in Lake Huron until the lamprey problem could be resolved.

The main issue was size—the St. Marys River is 25 times larger than any river ever treated with lampricide and, as such the use of TFM would have been neither affordable nor effective. Moreover, as an active shipping corridor, barriers would not have been remotely possible.

Through painstaking assessment work, the Commission and its partners determined that sea lamprey larvae were not evenly distributed throughout the St. Marys River, rather, are concentrated in "hot spots." As such, the entire river does not need to be treated with lampricide. Instead, the strategy has been to treat just the hot spots with a granular version of the lampricide niclosamide (called granular Bayluscide). Granular Bayluscide would sink to the bottom of the St. Marys River, dissolve slowly (much like time-release cold medication) just above the substrate, and kill the sea lamprey larvae living there.[24]

Given the size of the river, however, and given the entire system could not be treated (just the hot spots), granular Bayluscide alone would not be sufficient, most thought, to manage populations on the St. Marys River. The Commission determined that granular Bayluscide should be combined with the SMRT to implement a two-pronged approach to sea lamprey suppression. This innovative approach, thus, combined a new formulation of the lampricide and a new sterilization technique. Certainly, this approach was the epitome of integrated pest management.

Starting in 1987, the St. Marys River was the test site for the SMRT. In 1997, SMRT became the major sea lamprey control technique on the river and in 1999, granular Bayluscide was added to the mix. The first applications of granular Bayluscide were done by helicopter in 1999 (an off-season crop duster did the job) and the results of those two approaches, although less dramatic and apparent than with conventional TFM treatments in typical Great Lakes streams, was apparent within a decade. Fish stocking resumed in Lake Huron and sea lamprey populations, by 2016, were at 30 and 20 year lows in Lakes Huron and Michigan, respectively, which supported a combined fishery worth more than $1 billion annually.

An assessment of the novel techniques for the St. Marys River, however, yielded some surprising results: the granular Bayluscide applications were likely responsible for the reduction in sea lamprey abundances while the SMRT could not be evaluated for its contribution to control.[25] In other words, while the innovative Bayluscide worked, the effectiveness of SMRT was not able to be determined. As such, the Commission, in the late-2000s, invested in boats capable of delivering granular Bayluscide to the lamprey hot spots, and put the SMRT in abeyance in 2011. SMRT funds were re-directed to more cost-effective methods.

As the Commission learned with the crude mechanical and electrical weirs of the 1940s and 1950s, innovation does not always work out as predicted. However, as the Commission also learned over time, previous techniques that do not always work as planned can lead to better innovation. Just as barriers improved because of the knowledge gained from disappointments, the SMRT—because of the considerable work that went into its development—remains a viable control method in inland lakes and places of low sea lamprey density, particularly where lampricides and barriers would prove to be less desirable or effective. As always, the Commission takes full advantage of knowledge gained from every innovative technique it develops.

The Future of Innovation: Pheromones, Genomics, Barriers, and Traps

As the Commission says in its strategic vision, "The probability of reaching [sea lamprey] control targets can be tipped appreciably more in the Commission's favor if new technologies can be implemented to increase suppression beyond that achieved by the application of lampricides and the existing barrier network."[26] In other words, innovation never stops at the Great Lakes Fishery Commission. The Commission and its partners have created an ambitious vision for the future of sea lamprey control that may take decades to achieve – but the potential dividend of investments in research and development will likely be huge. Thanks to the Commission's science program and the Great Lakes Restoration Initiative, major advances in new control methods have occurred. As soon as new techniques have been field-tested and proven to be effective, they will be deployed in the field.

Why does the Commission devote resources and attention to innovation? Because innovation has brought us to where we are today and innovation will allow us to keep up with ever-shifting challenges, both from sea lamprey as they try to expand their range and by society as it shifts its values. For instance, the Commission is quite aware that it has been granted a social license to use lampricides in the Great Lakes and that such a license comes with expectations. Moreover, the Commission is aware that society is becoming less tolerant of dams and obstructions in rivers, particularly as older, more obsolete structures deteriorate and, thus, become more costly to maintain. Society, indeed, demands the minimal, most judicious use of pesticides and favors rivers that flow more freely. Although the Commission anticipates barriers and lampricides will

continue to be essential elements of the sea lamprey control program, we are also optimistic that innovative technologies can usher in a new era of control that continues to fulfill Vernon Applegate's vision for an integrated pest management program.

The future of control will certainly lie in a deep understanding of what makes a sea lamprey tick. Just as work in the 1940s and 1950s to understand the sea lamprey's life cycle led to the discovery of lampricides and other techniques, work conducted over the decades, and continuing today, will further unlock sea lamprey biology and identify specific traits that can be exploited for control. Several approaches are emerging as particularly promising:

The sea lamprey genome: During the past decade, sequencing the genome of a species has gone from a monumental, expensive, multi-year endeavor involving massive computing power, to a quick and cheap process that almost can be done on a home computer. Genetic technologies could help in the control of harmful fish, including sea lamprey.

The sea lamprey genome has been sequenced, providing an understanding of the genes that determine the animal's behavior and physiology, such as migration, mating, and responses to danger and environmental stressors.[27] This monumental achievement will allow scientists, for years to come, to customize control techniques to exploit points of weakness that interrupt the sea lamprey's life cycle. No other aquatic pest control program has this advantage, and the commission is intent on using genomic knowledge to develop innovative tools and tactics for suppressing sea lamprey populations.

One example of how genetic technologies could help control sea lampreys is through a technique called "gene knockdown." Gene knockdown could manipulate sea lamprey development, such as focusing on fertility genes (rendering sea lampreys sterile) or producing only males or females. Such genetic technologies are already yielding success in other species and in fishery management in other parts of the world.

Pheromones and alarm cues: Sea lampreys have an extremely well-developed sense of smell; their nose is half the size of their brain and loaded with receptors that allow them to detect pheromones and other odors (particularly those selective to lamprey) over large distances and in minute concentrations. Influencing sea lamprey behavior, primarily during migratory and mating periods, through the use of pheromones and alarm cues – natural odors used by sea lampreys to communicate – is another central theme of the sea lamprey research program. Lampreys, it was discovered, require a sex pheromone to locate each other for reproduction. Such a need turns out to be a tremendous weakness in the lamprey's life history and one that can be manipulated. Pheromones could be used to guide sea lampreys to areas that can be treated effectively with lampricides or into traps (i.e. pull). Alarm cues, by contrast, may be used to prevent sea lampreys from entering streams or areas that are difficult to treat or trap (i.e. push). Using both types of signals in concert as "push-pull" techniques could provide synergistic benefits beyond the use of a single signal.

The use of pheromones and other cues has actually long been considered as having a high potential for control. Research since the 1990s, supported by the Commission and later supplemented by the Great Lakes Restoration Initiative, has led to the discovery of several pheromones and alarm cues that affect sea lamprey behavior. Such research into the use of pheromones and cues in a *vertebrate* species is unprecedented.[28] In 2016, the U.S. Environmental Protection Agency approved the use of a Commission-developed pheromone (called 3KPZS) as a biopesticide for sea lamprey control. This approval paves the way for the development of other pheromones and cues in sea lamprey control. The Great Lakes Restoration Initiative has provided funds to move the pheromone program from the laboratory into the field. The Commission is hopeful that within ten to fifteen years, pheromones and alarm cues will be used throughout the basin as an integral complement to lampricides, barriers, and traps.

Acoustic telemetry: Many Great Lakes fishes, such as sea lamprey and lake trout, migrate throughout their lives to feed and reproduce. Until recently, scientists could only guess at fish movement. Starting in 2010, with funds seeded by the Great Lakes Restoration Initiative, the Commission has developed a Great Lakes Acoustic Telemetry Observation System, a network of innovative technology that tracks the precise movement of fish, aids in the recovery of native species, and helps us better understand the sea lamprey.

The acoustic telemetry network consists of nearly 2000 receivers – small, data-logging computers – that are anchored near the bottom of the lakes. To date, more than 30 species of fish (and 6000 individual fish) have been tagged with transmitters that broadcast a series of "pings" into the surrounding water. The receivers "listen" for tagged fish and the transmitter's unique ID code is saved with the date and time. Tens of millions of pings have been recorded. With each ping, researchers learn more about fish movements, migration patterns, habitat use, and survival. Receivers have been placed in key areas of the Great Lakes to help investigate specific research questions—for instance, walleye movement patterns in Lake Huron and the Huron-Erie corridor and lake trout spawning around Drummond Island, Lake Huron. Any scientist with the right tags can take advantage of this network. As the network grows the information and, perhaps, linkages among projects, grows as well. The Great Lakes network is now connected to the massive Ocean Tracking Network and the telemetry network in Lake Champlain.

Related to sea lamprey control, the project has shown that large populations of sea lampreys are hiding in the St. Marys River—existing in places where conventional assessment methods have been unable to detect. Through the acoustic telemetry project, researchers were able to collect better data on the size and location of the sea lamprey population in the St. Marys River. These data showed that the population in the river was much larger than previously thought, which allowed the commission to increase the efficiency of its sea lamprey control program and to redirect $500,000 annually to improve control throughout the Great Lakes

Connectivity and smart sea lamprey barriers and traps: Interrupting the migration of sea lampreys – either as downstream-migrating parasitic juveniles that have recently metamorphosed from larvae or as upstream-migrating adults – by diversifying and improving the network of barriers and traps is another strategy that could improve sea lamprey control. This strategy is attractive not only because it involves blocking adults from thousands of miles of suitable reproductive habitat, but because it also addresses the removal of parasitic juveniles before they enter the lakes to feed on fish.

The vast majority of barriers in the Great Lakes basin were neither constructed for sea lamprey control nor are owned by the Commission and, thus, are out of our hands. However, without those barriers, sea lamprey control would cost tens of millions of dollars more each year, if it even would be possible. The Commission is concerned that with the general trend towards dam removal, the sea lamprey range will expand, millions more fish will be killed each year, and control will become prohibitively costly. And yet, the Commission strongly supports measures taken by public and private interests to remove barriers to fish passage, as fish need rivers and barriers prevent connectivity between streams and the Great Lakes. Just as barriers protect the fishery from the deadly sea lamprey, they also impede fishery rehabilitation by keeping fish from their spawning grounds or from feeding habitat.

This "barrier schizophrenia" is not unique to the Great Lakes basin. Fishery managers all over the planet are challenged by how to block bad things like sea lamprey and pass good things like trout, salmon, walleye, and sturgeon. The Great Lakes Fishery Commission believes that smart barriers, with the use of innovative technologies, can solve this problem and, as such, launched in 2016 an innovative initiative called FishPass.

FishPass seeks to identify smart technologies that can sort a mixed assemblage of fish. Just as municipal recycling facilities separate glass, plastic, and newspaper from a single stream (and kicks out non-

recyclables like foam and tires), the Commission believes technology can sort fish that congregate at an obstruction like a dam or a barrier. Recently, and in consultation with a wide range of government and non-government experts, the Commission selected a dam in northern Michigan as a site to test innovative fish passage/lamprey blocking technology. Over the next few years, scientists, biologists, and engineers will work with fishery managers at all orders of government at this test site to identify and install promising technology, evaluate the effectiveness of the technology, and make recommendations for future use, if appropriate. If this project proves successful, it could solve one of the greatest fishery management challenges of our time.

As the issue of restoring the natural flow of aquatic systems gains momentum, the commission and its partners are committed to developing a cohesive process for proposing, evaluating, and implementing barrier construction and removal projects. The commission believes such projects must incorporate designs to stop invasive species, protect species at risk, prevent the movement of contaminants and disease, facilitate the passage of native migratory species, and improve recreation. Improvements in barrier design and trapping will help the commission meet these objectives.

INNOVATIONS IN GOVERNANCE

Most of this testimony has focused on innovations in science and technology in the control of the sea lamprey. I would be remiss if I did failed to note that the sea lamprey control program would not be the success it is without the innovative governance arrangement in place since 1954. Governance is important, and what is achieved is often a reflection of how people go about achieving it.

Sea lampreys swim across borders with wild abandon and spawn throughout the Great Lakes basin. As they spread in the 1920s through the 1950s, they posed a considerable threat to fishery management because containing and controlling the species required a level of cooperation across borders that was absent and certainly not at all in the culture at the time. In 1942, for instance, a Canadian-U.S. International Board of Inquiry noted that fishery collapse and sea lamprey spread was largely due to a parochial, jurisdictionally based approach to management.[29] Cooperation across borders was nonexistent and the fishery suffered because of that. Moreover, the lamprey invasion proved far too large a problem for any one jurisdiction to handle.[30]

By the 1950s, the sea lamprey problem, as noted above, was intolerable, and Canada and the United States agreed to the Convention on Great Lakes Fisheries of 1954.[31] The convention created the bi-national Great Lakes Fishery Commission, consisting of prime-ministerial and presidential appointees from both nations, who would lead fishery science, cross-border cooperation, and, importantly, sea lamprey control. This governance arrangement, which included an on-the-ground, bi-national, border-blind program, was unique in the Great Lakes basin and greeted with both applause from those who wanted the lamprey to be addressed and trepidation by those who were concerned about the Commission over-reaching its authority.

This testimony has described in detail the importance of the Commission's science program in developing innovative sea lamprey control techniques. The Commission also has played an integral role in helping the state, tribal, provincial, and federal fishery jurisdictions work well together on the Great Lakes. It is one of the best examples of sound science and good policy working together for the benefit of the Great Lakes. This success in fostering collaboration is largely due to the fact that the convention explicitly prohibits jurisdictions from interfering in the Commission's authority but also explicitly prohibits the Commission from intruding in the other jurisdictions' authority. The convention acknowledged that cooperation would be necessary to achieve sound fishery management. Among other things, the Commission works closely with the other jurisdictions to ensure sea lamprey suppression is consistent with their fishery management programs. For instance, the states, the tribes, and the Province of Ontario depend on the Commission to control sea lamprey at levels that allow them to stock fish and issue fish harvest regulations.

In addition to the science and cross-border collaboration mandate found in the Convention on Great Lakes Fisheries, the governance arrangement is also unique in that is puts a specific agency—the Commission—in charge of controlling an invader. Responsibility (and, thus, accountability) for sea lamprey control is unambiguous. This authority stands in sharp contrast to other invasive species that are widely dispersed; where responsibility to act is either vague or, like the pre-convention situation, too diffuse to make a difference.

CONCLUSION

The sea lamprey control program is widely viewed as one of the world's best examples of an alleviated environmental disaster. Sea lamprey populations have been reduced by more than 90% in most parts of the Great Lakes, which saves tens of millions of pounds of fish each year, supports 75,000 jobs, and contributes to a $7 billion fishery that is the envy of the world. This control program has been possible through innovation, science, technology, and the courage to try new things. It is important to note that had the Commission stopped innovating in 1957 with the discovery of TFM, it could not afford—either in monetary or social-license terms—to control sea lampreys in the Great Lakes basin.

The sea lamprey has taught some tough lessons, which we would be well-served to heed as we consider other threats like Asian carp and zebra mussels:

- A single invasive species can cause significant, permanent damage to the economic and ecological health of a region. We are fortunate that sea lampreys can be controlled, but sea lampreys remain a permanent, destructive element in the Great Lakes basin. Most—if not all—fishery management decisions made by federal, state, tribal, and provincial agencies must forever account for sea lampreys.

- Control of invasive species, if possible, is expensive and ongoing. The commission has spent more than $450 million (actual; cumulative) since 1956 controlling sea lampreys. This total amount over sixty years, while large, is still just a small percentage of the annual $7 billion value of the fishery. This figure does not include the immeasurable damage to the ecology of the Great Lakes basin.

- Prevention is key; eradication is not possible. The Great Lakes fishery will forever contend with sea lampreys.

- Citizens shoulder the costs and consequences of invasive species, and programs to manage invasive species are costly and often borne by taxpayers.

The sea lamprey control program, though, has also taught us the value of innovation. As chairman of the Great Lakes Fishery Commission, I can tell you the future looks bright. I am confident in two things: first, not all of the innovative tools under development will lead to viable control techniques but second, the only way we will find the new tools to keep us ahead of this noxious predator will be through innovation.

I thank the committee for holding this important hearing and for allowing the Great Lakes Fishery Commission to tell this exciting, hopeful story.

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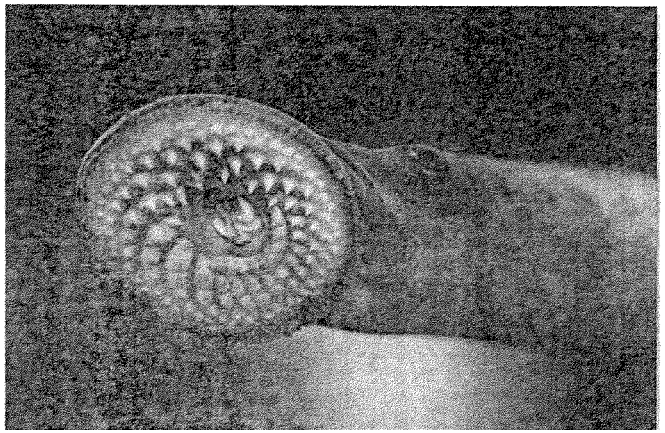
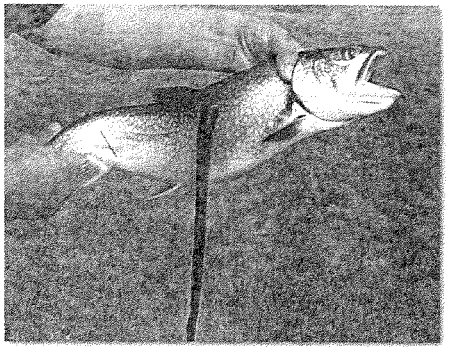
Figure 1: Parasitic sea lamprey (actual size: approximately 60cm). Drawing: Paul Vecsei.

Figure 2: Sea lamprey mouth (shown approximately actual size). Photo: Ted Lawrence, GLFC



Figures 3A and 3B: Sea lamprey (A) attached to a Great Lakes lake trout and (B) mouth and wound on a Great Lakes salmon. Photos: Marc Gaden, GLFC.

A



B

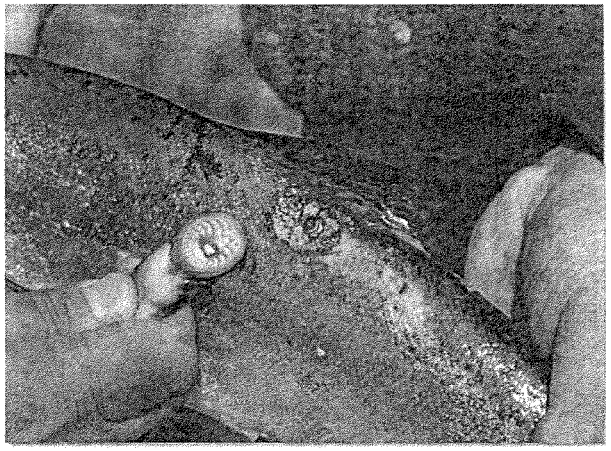


Figure 4: Decline of lake trout after sea lamprey enter the Great Lakes. Diagram: Marc Gaden, GLFC.

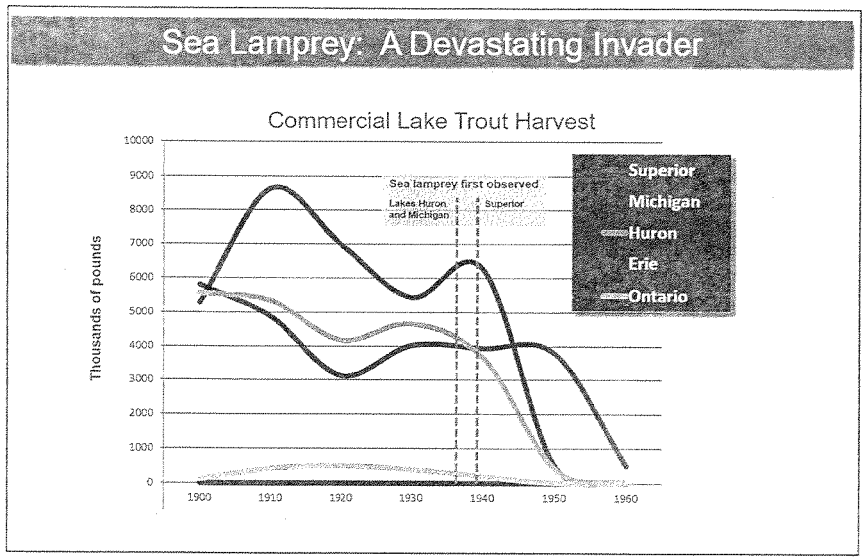


Figure 5: Sea lamprey abundance by lake compared to abundance target range. Diagram: Michael Siefkes and Marc Gaden, GLFC.

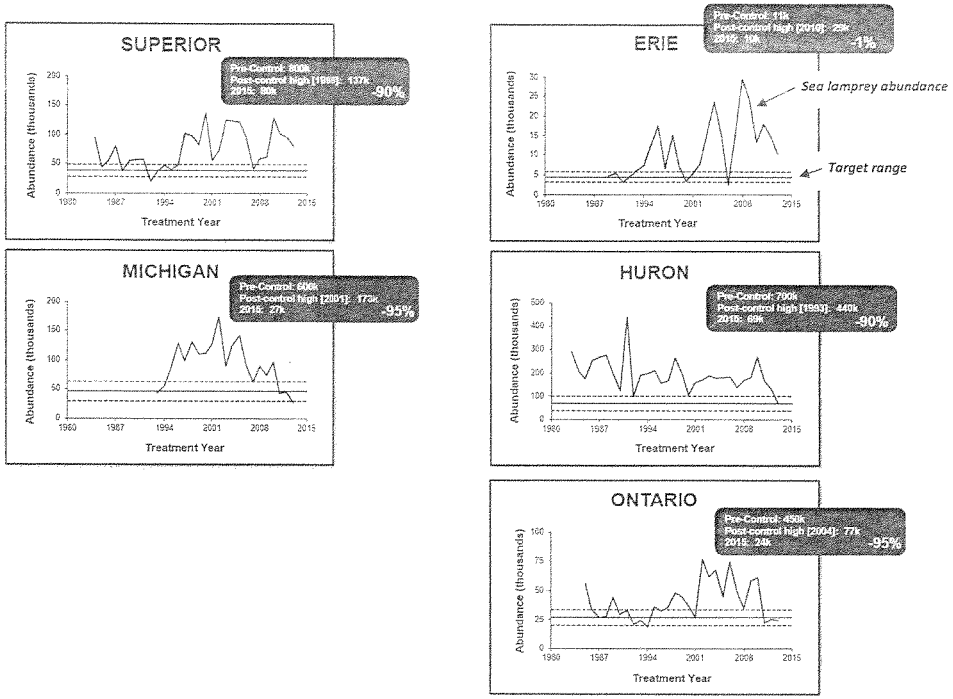
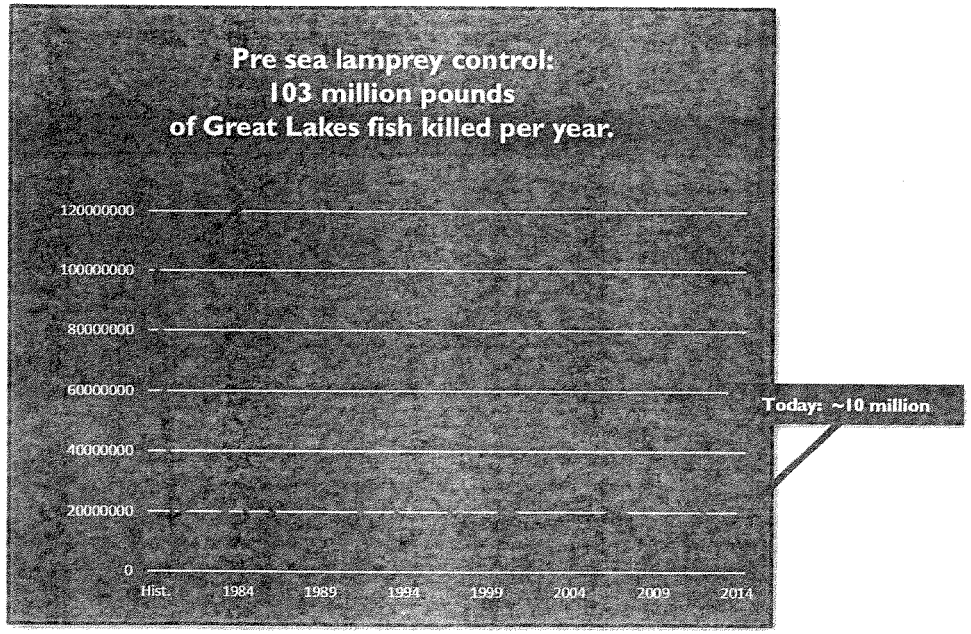


Figure 6: Millions of pounds of Great Lakes fish lost to sea lamprey. Diagram: Marc Gaden, GLFC.

1957-2017: Sea lamprey populations have been reduced by more than 90%. The result is a savings of more than 90 million pounds of Great Lakes fish per year that otherwise would have been killed by sea lamprey.



Senate Environment and Public Works Committee
Hearing entitled, "Examining Innovative Solutions to Control Invasive Species and Promote Wildlife Conservation"
March 15, 2017
Questions for the Record for Mr. David Ullrich

Chairman Barrasso:

1. Mr. Ullrich, if invasive mussel larva mature and propagate, they can block hydropower and irrigation ducts, as well as wreak havoc on ecosystems, recreation, and tourism. You discussed the significance of the financial impact in your testimony. How do you think we effectively communicate the national risk to the recreation community who may not live near these bodies of water?

The best way we can effectively communicate the national risk to the recreation community who may not live near these bodies of water is to inform them using as many communication avenues as possible, including traditional media, social media, state agencies, local governments, non-government organizations, and others. The key messages are that aquatic invasive species (hereafter referred to as "invasive species") are highly mobile and have the potential to cause major economic and environmental damage. Many details about their mobility and damage potential are illustrated below.

Invasive species, mussels or otherwise, are costly to everybody, not just to those who live near infested bodies of water. As suggested in the question, invasive mussels harm power plant operations, water utilities, industries that rely on water intake, agriculture, recreation, and many other sectors. Everybody pays the price of ecosystem harm, and direct costs associated with managing species are passed along to consumers. Moreover, other control costs (by any order of government) are usually borne by the taxpayers.

Invasive species are good at swimming or hitching a ride into new ecosystems. The Corps of Engineers' 2012 Great Lakes Mississippi River Interbasin Study[1], for instance, noted that 22 species from the Great Lakes threaten to invade the Mississippi River system and ten Mississippi species threaten to invade the Great Lakes. The threat comes from a manmade connection—called the Chicago Area Waterway System—that acts as a "revolving door" for invasive species. A species introduced into the Great Lakes has a high chance of making its way into the Mississippi system, and vice versa. Because most water bodies throughout North America are either connected directly or are accessible by users, a species introduced into one part of the continent has a good chance of making its way to areas far from the initial introduction. Inland lakes and other bodies of water are not immune from invasion given the large amount of boat traffic.

Exotic mussels, such as zebra and quagga mussels, are indeed a major problem and epitomize the need to emphasize the national risk invasive species pose. Zebra mussels were introduced into the Great Lakes in the mid-to-late-1980s and by 1990 were seen in all five of the Great Lakes (in both Canadian and U.S waters). According to the U.S. Geological Survey[2], the mussels were found in the Illinois and Hudson Rivers by 1991; they were detected as far south as Tennessee

only a year later in 1992. The mussels continue to spread throughout public waterways, major river systems, and enclosed lakes (e.g., quarries, reservoirs) such that today, they are found in all but 13 of the continental states. Unfortunately, most experts believe zebra mussels will be in all of the lower 48 states in due time given the interconnected nature of waterways. Zebra mussels are also found in at least three Canadian provinces.

In many cases, the zebra mussel larva drift with the current, so continued invasion is inevitable. In other cases (such as with inland lakes, reservoirs, and quarries), boaters have the potential to inadvertently move the mussels (and other organisms) into new ecosystems. A recent article[3] in the magazine Boat U.S., for instance, warned recreational vessels operators that freshwater lakes in Texas are under threat from zebra mussels and asked the operators to clean, drain, and dry their vessels before moving them between waterways.

Communicating risk is important, and if recreational and commercial vessel operators are given the right information, they are likely to take steps to prevent the movement of species. Communicating risk, of course, should be conducted before a species invades, as once a species enters a system and makes the system home, it is likely too late to eradicate. In the case of recreational boaters, communications should occur at boat ramps (through signage and through direct contact by local educators), in trade publications, and through other media. The most effective communications include a list of specific things people can do to minimize the risk of inter-basin transfer of species like exotic mussels. In the Texas example, boaters were provided with three clear things to do: clean the boat, drain any bait or water tanks, and dry the vessel. Even better is for there to be equipment at the boat ramp that would facilitate positive actions—equipment such as a power-washer or a receptacle for unused bait.

In the case of the trade of live organisms (e.g., for pets, aquaculture, or bait), risk assessments should be conducted and communicated prior to any proposed importation of a new species. Today, such assessments are not done as a matter of course and consumers of exotic pets, live fish, or bait need to be aware that, if released, the organisms could become pests. Education should exist in multiple places: at the point of sale (e.g., a pet store, which could dispense information about how to handle pets), through the media, online when e-commerce is involved, conservation officers, and with the help of third-party experts like university extension agents. Beyond communications, the Great Lakes Fishery Commission has long supported the passage of legislation that requires a risk assessment before new species are imported into North America.

National education campaigns, such as the ANS Task Force's "Stop Aquatic Hitchhikers,"[4] provides leadership from federal agencies and go a long way to offer useful, effective information to boaters about how they can be a part of the solution. Similarly, the Habitattitudes[5] program, which represents a partnership among Sea Grant, the U.S. Fish and Wildlife Service, and the pet industry, provides educational materials and best practices to aquarium hobbyists, pond owners, and others about how to handle unwanted fish and plants. State and local extension professionals throughout North America interact with fishing club members, boaters, hobbyists, and industries to further educate about the national risk of invasive species. The Great Lakes Fishery Commission strongly supports public-private partnerships and the allocation of public and private resources (at national, state, and local levels) for educational efforts.

Another innovative approach, focused on the source side of invasive species, is a tool called the Great Lakes Detector of Invasive Aquatics in Trade, or GLDIATR[6], which is hosted by the Great Lakes Commission and funded through the Great Lakes Restoration Initiative. The tool trolls the internet for websites that sell harmful exotic species and then allows for the seller to learn about the potential harm such species could cause. In several cases, the seller was unaware about the risk. According to the Great Lakes Commission, many sellers have voluntarily changed the species they stock or altered their practices after receiving such educational materials. GLDIATR also provides information to consumers who unwittingly might have purchased invasive species.

Finally, Congressional hearings, like the one held on March 15 in the Committee on Environment and Public Works, are a major help in communicating the risk we all assume when it comes to invasive species, including harmful mussels. Such hearings draw attention to the fact that costs, while often hidden, are still present and significant.

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1 http://glmris.anl.gov/
2 https://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/
3 Boat U.S. Magazine, February/March 2015.
4 http://stopaquatichitchhikers.org/
5 http://www.habitattitude.net/
6 http://www.glc.org/work/gldiatr

Senator BARRASSO. Well, thank you very much for your thoughtful testimony.

I appreciate all of the witnesses.

We will start with some questions. Some of the Committee members may need to come and go, so if we don't have a chance to get to all the questions, some may be submitted in writing, and we would ask you to respond to those.

But I wanted to start with Mr. Kurth and then ask Mr. Nesvik to weigh in as well.

Mr. Kurth, in your written testimony you highlight the success of the Partners for Fish and Wildlife program. You called it a primary tool for collaboration with landowners. Should this program be reauthorized? What role should the program have when it comes to fighting invasive species and promoting wildlife conservation?

Mr. KURTH. The Partners for Fish and Wildlife program, in my opinion, is one of the most effective programs the Fish and Wildlife Service has. We not only do great work, but we leverage our investments sometimes 4 to 1 or even more. The Administration hasn't taken a position on an authorization bill, so I can't comment on specific authorization, but certainly the Fish and Wildlife Service wants to see this important conservation work continue into the future.

Senator BARRASSO. So, Mr. Nesvik, can you tell us if you agree that the Partners for Fish and Wildlife is an effective tool and is working for Wyoming?

Mr. NESVIK. Yes. Thank you, Mr. Chairman. I would agree with Mr. Kurth. Yes, in our experiences in Wyoming over many, many years of working with landowners, this program has been marked with success. Landowners particularly like this program because it is voluntary, the matching requirements are more flexible than some of the other government programs, and it is really focused work that is partnership-focused.

There is a project that is currently going on in partnership with the National Invasive Species Council, private landowners, the Department, the University of Wyoming, our weed and pest districts, BLM, Forest Service, NRCS, many, many partners to focus on new biological controls for some invasives. So that is just one of many, many examples. In Wyoming, though, in the past, this Partners program has focused mainly on wetlands and then also on invasive species work with private landowners.

Senator BARRASSO. Thank you.

Mr. Roberts, you mentioned the article from the New York Times yesterday that I have here. It is a watchful eye on wildlife coming out of Malawi. Very thoughtful. It features the World Wildlife Fund's partnership with Google. As you mentioned, use of imaging and drones to combat the poachers. It mentions some limitations of the drones, like the need for human operators who may be distracted to monitor other activity in order to detect poachers and raise alarms.

Noted in the article are nonprofit university researchers, as well, developing software that can be differentiating between humans and animals so the rangers can be automatically alerted when there is a good chance that poaching is occurring and they are detected.

Do you believe things like the XPRIZE competition could encourage innovative efforts that would then maximize the ability of drones to fight poaching and to develop maybe other technologies that could also help solve wildlife conservation challenges?

Mr. ROBERTS. Yes. Having been in the Maasai Mara with the FLIR cameras late at night, you do see poachers. But you are also reminded by how many animals there are out there, and it is like Grand Central Station. New technologies, these XPRIZES are extremely helpful. We were a part, through traffic of USAID, XPRIZE competition that ended up generating some incredible breakthroughs on funding whistleblower programs, machine learning technologies to help track illegal trades, genetic programs to help track the trade in pangolins which is like an armadillo on steroids. It is the most traded animal in the world. And we love these XPRIZE competitions as long as when you award the prize, you have thought about how do you implement the winner over time, and that requires capacity and accompaniment on the ground.

Senator BARRASSO. Thank you.

Mr. Nesvik, on technology we talk about the issue of drones. Clearly, drones can help reduce poaching. Can you tell us what steps Wyoming Game and Fish Department is taking to ensure respect for our constitutional rights, the constitutional rights of Americans when deploying advanced technology like drones?

Mr. NESVIK. Certainly, Mr. Chairman. First of all, the work that we have begun to explore, we haven't had a lot of opportunities because of the limitations of lower cost UAV technology. We haven't had a tremendous amount of opportunity to use them with a law enforcement application to this point, but some of the things that we have considered as we have thought through that is the fact that the activities that we would focus UAVs on would be activities that we would otherwise be able to do in a manned aircraft; you would simply be doing it with a lighter payload and without anybody in the airplane.

Second, in a very targeted and focused manner in places where illegal activity is known to exist, for example, in Wyoming, in our western mule deer winter ranges, we know every year that there are folks that are out there attempting to take advantage of very vulnerable big mule deer that are worth a lot of money and that are also worth a lot to those folks that choose to exploit them. So focusing the use of UAVs in places where we know there is criminal activity on public lands helps to really ensure that we are staying well within the bounds of the Constitution.

Senator BARRASSO. Thank you very much.

Senator CARPER.

Senator CARPER. Thanks.

I mentioned during my opening statement the publication National Geographic late December talking about the agreement that had been reached by our president and the former president of China, and it was actually a very encouraging article. Should we be encouraged by that agreement in terms of what it means for the trade of ivory in that country, those countries, our Country and around the world? Should we be encouraged or not?

That would be for anybody.

Mr. ROBERTS. I would be happy to address that.

Senator CARPER. Please.

Mr. ROBERTS. It was a groundbreaking commitment on the part of China. They committed to close their market within a year, by the end of 2017. China is by far the biggest market. And so that is going to make a huge difference. It is enormously encouraging.

But the wellspring of that announcement on the part of China was the announcement on the U.S. to do the same, and the U.S. moved first. So these bilaterals between countries are essential. And now we just need to help the Chinese government execute against this commitment, and our program in China is working to do that by creating lots of public awareness and demand for non-ivory products as wedding gifts and beyond.

Senator CARPER. All right, thank you.

Mr. ROBERTS. Huge gamechanger.

Senator CARPER. Good. Thank you.

If we were able to pursue all the ideas that you discussed here in your oral testimony and your written testimony today, if we were able to pursue all those ideas today, how might that affect the number of species that end up on threatened or endangered species lists?

Would you like to go first, Mr. Ullrich?

Mr. ULLRICH. I am sorry, could you——

Senator CARPER. No, I only say it once.

Mr. ULLRICH. OK.

[Laughter.]

Mr. ULLRICH. The endangered species or the invasive species? I am sorry, I was——

Senator CARPER. I will just restate the question, OK?

Mr. ULLRICH. Yes. Thank you.

Senator CARPER. You have given us a lot of ideas in your written testimony and your oral testimony. If we were able to pursue them all, or most of them, that you discussed today, how might that affect the number of species that end up on threatened and endangered species lists?

Mr. ULLRICH. Boy, that would be hard to tell. I would have to get back to you on that one. We really have to prioritize on the ones that we deal with, as opposed to dealing with all of them. And certainly, sea lamprey has been the top concern. The biggest threat coming in, which really could have an effect on a lot and perhaps lead to endangered species, is the Asian carp, and a tremendous amount of work has been put forward toward that. So holding back the invasive species does, I would hope, keep the endangered species list shorter.

Senator CARPER. All right, thank you.

Others, please. Mr. Kurth.

Mr. KURTH. I think that the problems around the world vary. I think that the illegal hunting and trafficking in wildlife in other countries, with these technologies we can greatly, I think, reduce the threat to many of these species. Of course, in the United States, legal hunting is an important management tool for us and it doesn't pose threats like that. But overall, as there continues to be a growing population and stress on habitat, we are going to have to find techniques to maximize our management capability.

In this day and age, wildlife need management, and the secret for us to keep things from getting in trouble is to have good habitat that is well managed by professional managers.

Senator CARPER. All right, anyone else on this question? Yes. Dr. Reaser?

Ms. REASER. I am happy to take the invasive species perspective. There was a study done over a decade ago now, maybe 15 years ago, by David Wilcove and colleagues that estimated that 42 percent, at least, of the endangered species that are listed are driven in that direction by invasive species impacts. So anything that we can do to reduce the current pressures that invasive species have on our native flora and fauna, and prevent new invasives from entering the Country through these technologies should reduce not only the pressures on those animals and plants that are currently listed, but on those that might be heading toward the listing process.

Senator CARPER. All right, thanks. If we have a chance for a second round, I don't know that we will, but, Colonel Nesvik, I want to come back and ask you to talk with us about someone might hear about this hearing today and hear us discussing the Partners for Fish and Wildlife, how might they participate. It sounds like a lot of folks are, and it is good for them and for our planet. So I want to come back and ask you more about that. Thanks so much.

Senator BARRASSO. Thank you, Senator Carper.

Senator INHOFE.

Senator CARPER. By the way, we have another colonel here, right over there.

Senator INHOFE. We do?

Senator CARPER. Army. Army.

Senator INHOFE. We do, we do.

First of all, let me say to Mr. Kurth I am glad we talked for a little while about the Partners for Fish and Wildlife, because when Dan Ashe had that job, during his confirmation I extracted from him a commitment to come out to Oklahoma, and he actually did two of them out there in western Oklahoma. And I really believe, in spite of the fact that, as a general rule, Democrats normally like to have things emanating from Washington, but I think it was an eye-opening experience.

Did you ever talk to him about the trips that he made out there? One was in Woodward, where I happened to have been this past Sunday; and the other in the southwestern part of Oklahoma. But it showed very clearly that the owners, the landowners are every bit as, are more concerned about the conservation issues on their lands than are the bureaucrats in Washington.

Mr. KURTH. Senator, I have talked to Dan many times about those trips, and I think he found those very insightful and instructive. People who make their living off the land, by the very nature of their business, have to be good stewards. A rancher is not going to make a living if he is not properly managing his grazing regimes. There is a saying that became famous during the sage grouse planning that is what is good for the bird is good for the herd. That came from a rancher in Oregon.

Senator INHOFE. In a minute, I will talk about the burying beetle, and we will see if that fits in.

Mr. KURTH. Well, the burying beetle is a little different critter. [Laughter.]

Mr. KURTH. I didn't think we would avoid that one today.

But, yes, we work hand-in-hand with ranchers. Two-thirds of the wildlife habitat in this Country is on private land.

Senator INHOFE. And the owner of the land is the one who is most concerned about it. I think that was a good move that we made, and we have been trying to enhance that program in answering the question. If you find out for any reason you don't think it is going to be authorized, let us know, because we can encourage that.

I want to just mention one thing about the hunters and the fishermen, the contributions that they make, the fact that not just in the funding through the duck stamps and all the contributions they make through excise tax on firearms and so forth, but they really are involved. And I would ask perhaps both of you, Mr. Nesvik and Director Kurth, if you can both speak to the hunting and fishing communities and the conservation and the positive impact they have, and then maybe even move on to how they can be used more effectively in the invasive species. I know that in our case, in the State of Oklahoma, wild boar and some of these others, we are in a position to be used better than we are being used now.

Any comments that you can make on that?

Mr. KURTH. Well, certainly sportsmen are the original conservationists in this Country, going back to President Theodore Roosevelt, a founding member of the Boone and Crockett Club, and their work all across this Country——

Senator INHOFE. What club?

Mr. KURTH. The Boone and Crockett Club, a great sportsmen's organization that still exists today.

Senator INHOFE. I don't belong to that one, I don't think.

Mr. KURTH. He established our first national wildlife refuge and 50 other national wildlife refuges. Sportsmen have been involved in almost every aspect of our business, from being members of local hunt clubs that sponsor projects to working with us on invasive species. We have active volunteers in invasive species, and they do more than just train.

One of the easiest things that takes manpower is to actually go out and map where these invasive species are so strike teams and others can come behind, and we can give sportsmen or other volunteers a GPS unit and they can take a stroll out on the land and help us to learn and map so our treatment can be more effective. There is almost no end to the number of innovative ways that sportsmen help.

Senator INHOFE. Do you agree with that, Mr. Nesvik?

Mr. NESVIK. Yes, Senator, I do. And I can tell you that from my experiences in Wyoming and other western States, including Oklahoma, I have colleagues in Oklahoma that I have worked with often, and I can tell you that there is no one more interested in wildlife management agencies doing a good job of protecting their resource than sportsmen. And, as Mr. Kurth indicated, since the beginning of wildlife conservation in our Country, they have been a major part of that and really the founder.

Senator INHOFE. They are also paying for a lot of that stuff, too.

Now, I do want to get around to one question, and I would like to have you, Mr. Kurth, provide an update on where the petition to delist the American burying beetle stands today and when we should expect the 12-month review of the lesser prairie chicken petition.

Mr. KURTH. Well, Senator, let's start with the beetle. As you know, in March 2016 the Service made a substantial finding on the petition to delist the American burying beetle. Prior to receiving that petition, we had initiated a species status assessment to support future conservation decisions, recovering planning. That status assessment is drafted and is undergoing scientific peer review now, and we expect it to be complete this summer, and that status assessment will be the scientific underpinning.

Senator INHOFE. All right, this summer. Let's go, then, on to the 12-month review of the lesser prairie chicken.

Mr. KURTH. Yes. In that process, we expect to be able to make that determination by this September. We are awaiting the annual report from the Western Association of Fish and Wildlife Agencies and the result of their survey work that they have been doing here this spring to update and inform that species status assessment.

Senator INHOFE. Yes. We will be standing by. Thank you.

Senator BARRASSO. Senator Whitehouse.

Senator WHITEHOUSE. Thank you all.

I would like to followup on Senator Inhofe's comment about the important role of sportsmen in tracking and gathering information for us by echoing that fishermen have an equally valuable role. I very much hope that, as we proceed with the initiative, Mr. Chairman, which I appreciate very much, that we make oceans and coasts a significant part of this, as well as upland and fresh water.

As you know, our side of the aisle is heavily coastal. I think only Senator Sanders and Senator Duckworth aren't ocean coastal, and they have major lake coasts. On the other side of the aisle there tend to be a lot of, sadly, landlocked States. Their good news is that, with climate change, the ocean gets a little closer every day.

[Laughter.]

Senator WHITEHOUSE. The focus on oceans and coasts, though, is I hope one that we will maintain. We have seen enormous invasive species that are actually not just moving because of climatic changes that allow them new habitat that they didn't have access to before, but we see global shipping exploding and we see ballast water and things like that allowing for the transit of invasive species in a way that the land doesn't quite match. So I hope that we can focus on that.

I particularly want to thank the members of this Committee who are members of the Oceans Caucus, and I thank Senator Inhofe for joining our Oceans Caucus just recently, because one of the first things we worked on was pirate fishing; and we got four treaties passed, which may not seem like a big deal, but we did it in an afternoon. And to timespan the previous four treaties the Senate passed, you would have to go back 9 years. And we got the enabling legislation passed. And now, with those treaties and those laws and technology, we are starting to see some real damage done to pirate fishing.

One of the worst places was Indonesia. It is an archipelago of a lot of islands with a huge amount of ocean around it. Their fisheries minister, I think, has sunk more ships in this century than the United States Navy has. She is just constantly blowing up pirate fishing vessels and putting them to the bottom of the ocean. She actually had the Chinese more or less attack one of her vessels and carve away the one that they were trying to tow in to sink because it was a Chinese-based pirate fishing vessel.

But we are seeing satellite imagery and computers that can track the satellite imagery and look for fishing patterns. We are seeing technology that looks for when the transponders turn off in boats as a signal that now they are up to bad behavior because they don't want their transponders to track them. We are seeing signals in fish, particularly high value fish that you use to sort of track their whereabouts and see where they go, that suddenly end up in an amazingly straight line out of their habitat, going for days across the ocean toward a specific port, and then you know, guess what, they are onboard a ship that caught them illegally.

We have drones that have a role. And as Mr. Kurth and Senator Inhofe were talking about, there is a networking capability where, with GPS and simple phones that have camera applications, you can get a whole bunch of even very artisanal fisherman to simply take pictures of boats that they see out fishing, register where they are, triangulate, if you need to, nail down the identification, and use that as evidence to go out and enforce.

So the open ocean is no longer such a safe haven for this organized crime activity as it used to be thanks to all these steps going forward.

Let me just ask one question of each of you. I think it is a simple yes or no question. Do you model climate change projections into your invasive species planning?

Mr. NESVIK. Senator, as far as modeling climate change with regards to invasive species——

Senator WHITEHOUSE. Is that a factor in your planning model I guess would be a better way to ask the question.

Mr. NESVIK. Certainly. It certainly is.

Senator WHITEHOUSE. Carter.

Mr. ROBERTS. Yes.

Senator WHITEHOUSE. Mr. Roberts. Sorry.

Mr. ROBERTS. Yes. Factoring in climate change into all of our work, as the world is changing so much around us, is fundamental to making sure that our conservation efforts last.

Senator WHITEHOUSE. Mr. Kurth.

Mr. KURTH. It is a factor that we look at in all of our work, and sometimes it is very important; other times it is not the most significant factor.

Senator WHITEHOUSE. Ms. Reaser.

Ms. REASER. A number of the departments under the Council do as well.

Senator WHITEHOUSE. And Mr. Ullrich.

Mr. ULLRICH. Yes.

Senator WHITEHOUSE. Great. My time has expired.

Thank you very much for hosting this hearing. I think this is an area where we will be able to do some very good work together.

Senator INHOFE.

[Presiding.] Thank you, Senator Whitehouse.

Senator ERNST.

Senator ERNST. Thank you, Mr. Chair.

Senator Whitehouse, I do have water on either side of Iowa; it is the Mississippi River and the Missouri River.

Senator WHITEHOUSE. That is right. Rivers count too.

[Laughter.]

Senator ERNST. Thanks to our panelists today. It really is an interesting discussion, so it is good to have you here.

Dr. Reaser, I will start with you, please. In Iowa, one of our newest and most significant invasive species concerns is the Palmer amaranth. It is a weed native to southwestern United States. It entered into Iowa through conservation seed mixes. In early 2016, this weed was in only five of our Iowa counties; and by the end of last year it was in 49 Iowa counties. And it is expected to be in all 99 counties by the end of this year.

What concerns me and the agricultural community is that so much of this weed's potential impact harms our crops and the crop yields, and it has added costs to farmers. Studies have shown that it can reduce soybean yields by up to 80 percent and our corn yields by up to 90 percent. So that is very, very significant for our farmers. It also forces farmers to use herbicides and to utilize other eradication methods such as tillage on what is traditionally no-till land.

Is this an issue that is currently being tracked through the National Invasive Species Council?

Ms. REASER. Thank you for the question. It is a significant challenge and area of concern. My team, the Council Secretariat, was contacted by the U.S. Department of Agriculture with their concerns. We have a non-Federal advisory committee that includes stakeholders from seed trade organizations, and we did outreach through our relationships to alert stakeholders in the seed trade circles that this was an issue of concern and asked them to increase the vigilance and communications within their networks.

Senator ERNST. So you would say there is heavy collaboration going on between different local, State, and Federal agencies?

Ms. REASER. I can't speak to the agencies; the State and Federal agency representatives would be better spoken in that regard, but it has been brought to our attention and we did reach out to our stakeholders, recognizing the importance of the issue.

Senator ERNST. Very good. Yes, it is a very, very tough issue that we are facing right now, and I know many other States are, too.

Mr. Nesvik, thank you very much for your service. I appreciate it greatly, from one Guardsman to another.

Mr. NESVIK. And you as well, Senator.

Senator ERNST. Thank you very much.

When I examine a policy issue that comes in front of us, in this case an invasive species such as Palmer amaranth, and the management of that, as well as wildlife conservation, one of the first things that I look at is how State and local governments are working together to inform the Federal Government on its policy objectives. As a State wildlife official, do you think that the Federal partners that you are working with give you the discretion you

need to make the decisions that are right for you, right for Wyoming and its conservation efforts?

Mr. NESVIK. Well, Senator, that is an excellent question, and I guess the short answer to that question would be yes, because we have very mutual interests. The Federal agencies that we primarily deal with on these types of issues with invasive species in Wyoming are agencies that are land managers, so they have no interest in having invasive species dominating their landscapes and inhibiting their abilities to manage their lands.

So there is a mutual goal there between the State agencies and the Federal agencies. As we talked earlier about the Partners program of Fish and Wildlife, oftentimes those programs are executed with multiple Federal agencies, as well as private, nongovernmental partners when those things are executed.

So, again, maybe a little bit longer answer to the short answer of yes.

Senator ERNST. No, that is great. So that is where we see more of the collaboration going on, is through those channels, then.

Mr. NESVIK. Yes, Senator.

Senator ERNST. Very good. Well, I appreciate it. My time is expiring. I will yield back.

Thank you.

Senator INHOFE. Thank you, Senator Ernst.

Senator DUCKWORTH.

Senator DUCKWORTH. Chairman Barrasso, Ranking Member Carper, thank you for convening this important conversation. I want to extend a warm welcome to all of our witnesses, especially to Mr. Ullrich, who I claim as being from Chicago, having spent much time there, even though he now lives in a neighboring Great Lakes State.

These gems in the Great Lakes are home to the world's largest freshwater system. They provide over 40 million people with drinking water, 1.5 people with jobs, and generate billions of dollars a year in economic revenue. Approximately 15 percent of the U.S. gross domestic product originates within the Great Lakes basin. And as we have heard from Mr. Ullrich, the issue of invasive species is of great concern to the region. And while we have had some successes combatting these issues, we do need to prioritize issues within the invasive species battle.

Combatting invasive species in the Great Lakes can't simply be a zero-sum game, and we have to figure out a road forward that balances the role of the Great Lakes in our economy, as well as with the environment.

Mr. Ullrich, it is budget season here in D.C. and any day we will get the Trump Administration's proposal to fund the Government, including agencies like NOAA and EPA. Are you concerned that the budget cuts that we are expecting the Trump Administration to propose will hinder the region's efforts toward combatting invasive species?

Mr. ULLRICH. Thank you for the question, Senator Duckworth. Yes, we are very concerned. The funding for the Great Lakes Restoration Initiative has been a key element in keeping the Asian carp out of the Great Lakes, which could be one of the most devastating invasive species ever to come into the Great Lakes. All you

have to do is ask the people on the Mississippi River and the Illinois River and the Missouri River and these other rivers about what they have done to the fishery in those areas. That funding has been critically important. I believe over $150 million has been spent over the last 7 years to stem the tide of the Asian carp.

The continued funding through the State Department of the Great Lakes Fishery Commission is critically important to the sea lamprey. You have to keep on top of them; otherwise, they are going to come back and take over. They just don't go away.

So on the one hand the priority of the prevention of the Asian carp getting in and, on the other hand, the continued management of the sea lamprey is absolutely critical. It would be nice if it were free, but it is not.

Earlier questions came to the issue of the fishery community and fishers and commercial fishermen. They are fully integrated into the work that we have on the Great Lakes Fishery Commission, and they are our eyes, ears, and fishing poles out on the lake all the time and have a huge stake in it, and we incorporate their thinking. Local, State, Federal Government, Tribal Governments all work together on this effort. But really the lifeblood is the funding that comes through, and this could have a devastating effect on the Great Lakes if it were cut to the degree that has been discussed.

Senator DUCKWORTH. Well, in the case of the Asian carp, it is so invasive that you don't even need fishing poles; you just hold a net up above your boat and they jump right into it as you are driving along the Illinois river.

Mr. ULLRICH. They are quite dangerous for jet skiers, water skiers and others. I have seen it myself and it is pretty frightening.

Senator DUCKWORTH. Can you speak a little bit, when it comes to the bighead and the silver carp, to the role of locks and dams and needed investments in infrastructure, specifically integrating lock improvements with technology innovations at the locks that could allow barges to move, but also blocking the invasive species?

Mr. ULLRICH. One of the key things that we are looking at is an existing lock and dam system referred to as Brandon Road. Between the U.S. Geological Survey and a number of other Federal and State agencies and U.S. Army Corps of Engineers, they are looking at a number of different innovative approaches to allow the barges through, but to keep the invasive species in this situation from getting up to Lake Michigan, and we hope eventually to provide two-way protection between the Great Lakes and the Mississippi River as well.

There has been a temporary halt put on that work, which is very dangerous because we have been going too long and our luck is going to run out if we don't get those systems identified and put in place. So here the work with the Corps of Engineers, USGS, Fish and Wildlife, the State agencies, I represent local government in my day job, and all of this is really important, so going ahead on this Brandon Road project is critically important.

Senator DUCKWORTH. Thank you. I very much appreciate you being here and your many decades of work on this issue.

I yield back.

Mr. ULLRICH. Thank you.

Senator INHOFE. Thank you, Senator Duckworth.

Senator ROUNDS.

Senator ROUNDS. Thank you, Mr. Chairman.

Mr. Nesvik, I would like to talk a little bit more about Asian carp, as Senator Duckworth brought up the discussion. I appreciate the fact that you are here today to share your perspective as a State-based professional working to combat invasive species. In my home State of South Dakota, the Asian carp has become an emerging threat to not only our rivers and lakes, but literally, as pointed out earlier, the physical safety of boaters. In fact, they are known to leap out of the water several feet.

I understand from your testimony that you are optimistic about the use of next generation thermal cyclers to detect the species. Relying on your assessment of the beta testing currently being conducted, how you envision a State like South Dakota potentially employing this type of equipment?

Mr. NESVIK. Excellent question, Senator. First of all, I will tell you that the State of Wyoming is certainly interested in helping you with the Asian carp issue in South Dakota. Our approach with invasive species to this point has been to try to keep them outside of the borders of Wyoming, and so far we have been successful with that. Our primary threats have been with quagga and zebra mussels.

But the primary inhibitor with the use of those kinds of technologies right now, from a State agency's perspective, is the fact that their range for those UAVs that are cost-effective, those imagers that are cost-effective and affordable for a State agency, their ranges and their power requirements are such that they are not employable.

For example, a UAV that can range up to about 15 kilometers and has a flight time of an hour is about a $50,000 investment, so it is significant. And that is where I think there are opportunities for innovation to be able to make those kinds of technologies more cost-effective for a State.

Senator ROUNDS. So we have a ways to go before that is going to be something that is going to be in the picture in terms of a good tool to use with regard to invasive species like the Asian carp.

Mr. NESVIK. That is certainly my assessment.

Senator ROUNDS. Thank you.

Mr. Ullrich, thank you for appearing today. During my time in the Senate, and on this Committee specifically, we have seen the importance of sound science across government. In your testimony, you State that without the most accurate and complete scientific data, the inroads that were made reducing the presence of the sea lamprey would have been impossible.

You interact with a variety of different Federal agencies in your capacity as Chair of the Great Lakes Fishery Commission. What additional steps do you think the various Federal agencies can take to better develop scientific information to manage invasive species?

Mr. ULLRICH. Excellent question, Senator. First of all, I want to say that I believe, and I have been in this business for 44 years now, that at the Great Lakes Fishery Commission I have seen probably one of the best mergers of science and policy to come together. I think, No. 1, it is really important that policymakers do

listen to the scientists. No. 2, cooperative efforts among the scientists at Federal, State, to a lesser extent local level, but really important is the indigenous peoples and Tribal peoples. They bring an important perspective to this.

Obviously, it needs funding, but, very importantly, cooperation across whether it is State lines. We work very closely with Canada on almost all that we do. Some of the best risk assessment work has come out of the Department of Fisheries and Oceans in Canada. We incorporate that together.

I think if you were able to see the cooperative effort going on the Illinois River with Federal, State, local agencies, tribal groups, Canada, and the U.S., it is one of the best examples of cooperation on an effort like that, both at the scientific level and at the deployment level. We need much, much more of that. And having a common goal is really important, and having leadership articulate the importance of that goal does help to bring the scientists together with the policymakers and with the implementers. So that is very helpful.

Senator ROUNDS. Thank you.

Thank you, Mr. Chairman.

Senator INHOFE. Thank you, Senator Rounds.

Senator BOOKER.

Senator BOOKER. Thank you very much, Mr. Chairman. I am really grateful that the Committee is holding this hearing. Really, this is significantly urgent work, and I am grateful for the witnesses we have here.

Mr. Kurth, I would like to jump in, actually, on another issue. I understand that you have been a career professional at the U.S. Fish and Wildlife Service for 38 years, is that right?

Mr. KURTH. I have been working in conservation for 39 years; 37 with the Fish and Wildlife Service.

Senator BOOKER. Obviously, you must have gotten started in kindergarten, so I appreciate that.

Mr. KURTH. Bless you.

Senator BOOKER. Earlier in the career, though, you managed service for the Alaska Subsistence Program and you were manager of the Arctic National Wildlife Refuge for many years, is that correct?

Mr. KURTH. Yes, sir.

Senator BOOKER. So you know a little bit about, I think that is an understatement, managing wildlife and managing national wildlife refuges in Alaska, correct?

Mr. KURTH. Yes, sir.

Senator BOOKER. Are you familiar with the regulation published by the Service on August 5th, 2016, relating to the non-subsistence take of wildlife on national wildlife refuges in Alaska—and take is basically killing—the so-called Alaska Rule?

Mr. KURTH. Yes, sir.

Senator BOOKER. Do you have any doubt, or did the Department of Interior solicitor, the Department of Justice, or anyone express or at least those specific folks express any doubt or concern about the statutory authority of the Service to issue this rule?

Mr. KURTH. There was no concern about our authority.

Senator BOOKER. I am grateful for that, sir. And the rule only applies on national wildlife refuges, and does not apply on any private land or State-owned land in Alaska, correct?

Mr. KURTH. Correct.

Senator BOOKER. And what this rule does—I have the rule right here—is it prevents inhumane practices on our wildlife refuges such as specifically prohibiting the killing of mother bears together with their cubs, is that correct?

Mr. KURTH. That is one of the prohibitions, Senator.

Senator BOOKER. It also prohibits killing mother wolves and pups in their dens, correct?

Mr. KURTH. Yes, sir.

Senator BOOKER. It prohibits using planes to track and kill bears, right?

Mr. KURTH. Correct.

Senator BOOKER. And it prohibits using snares, which are these wires hanging around the necks of animals and steel jaw leg hold traps to kill bears on these national wildlife refuges, correct?

Mr. KURTH. Correct.

Senator BOOKER. Mr. Kurth, I think that this rule is vital, and I actually have a lot of, I will even use the word, love for one of my colleagues who is an Alaskan Senator who saw this more as a sovereignty issue. I don't want to get into that aspect of the debate or issue; I really am concerned about the inhumane treatment of animals and how this law, this rule specifically outlaws what I think are outrageous killings.

I don't think we should be allowing the killing of baby animals on our national wildlife refuges; this, to me, does not reflect who we are as a Nation. But I am sure that you know the House passed a CRA to abolish the rule and to prevent the Fish and Wildlife Services from ever adopting a similar rule to prevent these specific cruel practices. In other words, it is preventing the Federal Government from having the ability to stop what I believe are tragically cruel killing of pups and others.

You know, I think this is outrageous and really hope that my colleagues will carefully study this important Fish and Wildlife rule and decide not to support a CRA. And the intention was not necessarily around sovereignty, I imagine, which is something that is worthy of discussion and debate, and maybe for Congress to act on, but really the inhumane practices.

And the last question I will ask, Mr. Kurth, in terms of wildlife management, sound management, you do not need these practices to successfully manage a Federal wildlife refuge, is that correct?

Mr. KURTH. And that is the distinction to be made. The State of Alaska has their rules and regulations to manage wildlife under their State regulations, and I won't judge that, but on national wildlife refuges the laws are different, and we enacted the rule that we thought necessary to administer the national wildlife refuges in accordance with the Alaska Lands Conservation Act and the National Wildlife Refuge System Administration Act; not to pass judgment on cruelty, but to manage those refuges according to the standards that we have been given.

Senator BOOKER. OK. And it is not necessary, though, for the management to have those kinds of killing of pups and the steel

traps. It is not necessary to do successful management, is that correct?

Mr. KURTH. When we enacted the regulations, we did not find them necessary.

Senator BOOKER. Sot. I am grateful, again, for your years of service. Thank you for answering my line of questioning.

Thank you very much, Mr. Chairman.

Mr. KURTH. Thank you, Senator.

Senator BARRASSO.

[Presiding.] Thank you, Senator Booker.

Mr. Nesvik, any additional comments on some of the comments you just heard here from the last questioner? Did you want to weigh in on this discussion?

Mr. NESVIK. Mr. Chairman, I guess I wouldn't have anything to add. We certainly have a little bit different perspective in our State with regards to how national wildlife refuges are used, and those kinds of practices are not engaged in our few refuges that we do have in the State of Wyoming.

But, as Mr. Kurth indicated, there are some management tools that are humane and necessary, as long as they are regulated properly, that can be conducted that relate to some of those things that you talked about, Senator.

Senator BOOKER. Mr. Chairman, thank you for allowing Mr. Nesvik to make that point, because I think it is really important that these savagely cruel practices are not necessary, whether it is the State managing or the Federal Government managing. The reality is these are inhumane practices that should be prevented in the United States of America on our Federal wildlife refuges, and I am glad to have two witnesses now testify that is just not necessary to do.

Senator BARRASSO. Thank you for the clarification.

I want to thank all of you for being here today to testify.

Dr. Reaser, I know that Senator Sullivan had a couple of questions he is going to submit in writing because he is now in the chair as the presiding officer in the Senate, so he wasn't able to return for those questions.

I was not going to head for a second round of questions, unless you had any closing comments, Senator Carper.

Senator CARPER. Thanks so much.

I telegraphed my picture earlier with respect to just a practical explanation of how this partnership for fish and wildlife works. Could you just give us a practical, like if people, landowners, farmers were interested in joining, being part of this, how would they go about doing it?

Mr. NESVIK. Thank you, Ranking Member Carper. There is actually a backlog of interested parties, but basically when they have an interest they start with their local Fish and Wildlife Service person in their State and they begin the discussion, the dialog there, develop the project, determine what the goals may be, and that is when the other partners, specifically in my case, the State wildlife management agency, enters into the picture to kind of establish how the project may be completed, what the goals of the project may be, and other necessary partners. Then that is when kind of the next step after that is the development of those other

partners so that the money that is provided by the Federal Government can be leveraged, as Mr. Kurth indicated in his testimony.

Senator CARPER. All right, thank you.

Do any of you have anything else you want to add, given the conversation we have had, that you think is appropriate to add before we conclude? Please.

Mr. ULLRICH. Senator, if I might, I have to say again that I deeply appreciate the focus on invasive species. I think if you talk to most Great Lakes scientists, they would probably say that the most devastating impact on the Great Lakes of all of the pressures have been invasive species. They have seriously disrupted the biological balance, and anything more that we can do will really enhance the environment and the economy of the Great Lakes region.

Senator CARPER. All right, thanks.

Anybody else? Yes, please.

Mr. ROBERTS. I think it was Senator Inhofe who first raised this issue and Senator Whitehouse doubled down on it, and you just raised it as well, which is, both in the United States and around the world, it is the role of local communities and private landowners and indigenous communities who are at the heart of the most lasting conservation efforts.

And the discussion about technologies and approaches to deal with poaching and invasives, the more we can rest on and build on the ownership of local communities and private landowners here and abroad, the more lasting those results will be, whether it is our work in the northern Great Plains depends upon ranchers and Tribes, and our work in places like Namibia and Nepal depends on local communities and indigenous groups, and that is the strongest, most lasting form of conservation.

And I would underscore the points that have been made in that regard, and particularly as you think about XPRIZES or challenges in the area of technology, to find a way to give a nod to local communities and their use of technologies, I would encourage you to think about that.

Senator CARPER. Good. Thank you.

Mr. Kurth.

Mr. KURTH. I would just like to end with, sometimes it is easier to find a conflict between the Federal Government and the State, but our conservation ethic requires us to work every single day with our State colleagues. There is no stronger bond in conservation between the Fish and Wildlife Service and our State fish and game colleagues. We can't be successful without them, and I just wanted to tip my hat to them.

Senator CARPER. In Delaware, we value our partnership with Fish and Wildlife. I think your regional director is Wendi Weber.

Mr. KURTH. Yes.

Senator CARPER. And she has been to our State any number of times, along with others of her colleagues. Thank you for that partnership.

Senator BARRASSO. Well, thank you to each and every one of you for being here to share your testimony with us and to answer your questions in such a thoughtful manner. I thought it was a very productive hearing. I hope that you felt it was worth your time and effort.

We are going to keep the hearing record open for 2 weeks because there are some members that had to come in and out based on other obligations, and they will be submitting questions for the written record, and we would ask that you try to respond quickly to those.

Thank you. Since there are no other questions, the hearing is adjourned.

[Whereupon, at 11:41 a.m. the committee was adjourned.]

[Additional material submitted for the record follows.]

The New York Times https://nyti.ms/2ngTKbs

SCIENCE

High Above, Drones Keep Watchful Eyes on Wildlife in Africa

By RACHEL NUWER MARCH 13, 2017

LIWONDE, Malawi — Night has fallen at Liwonde National Park, but the trespassers are clearly visible. Three hundred feet in the air, a thermal camera attached to a BatHawk drone tracks their boat, a black sliver gliding up the luminous gray Shire River.

"They're breaking the law by coming into the park," said Antoinette Dudley, one of the drone's operators, pointing to her computer screen.

More than two miles from the boat, she and her partner, Stephan De Necker, are seated in a Land Cruiser that serves as their command center. A monitor attached to the driver's seat displays the drone's vitals, and another behind the passenger's seat streams live video from the camera, operated with an old PlayStation console.

"Let's give them a scare," said Mr. De Necker. With the tap of a few keys, he switches on the drone's navigation lights and sends it beelining toward the boat.

The reaction is instantaneous: The boat makes a U-turn, high-tailing it out of the park.

Africa is in the midst of a profound poaching crisis: The continent's elephant population declined by 30 percent from 2007 to 2014, much of it because of poaching. At least 1,338 rhinos were killed for their horns in 2015 alone. Criminals are becoming increasingly militarized in their tactics, and efforts to stop them have had little success.

Liwonde has lost about 50 elephants and two rhinos since 2014 to poachers. In August 2015, the Malawi Department of National Parks enlisted the help of African Parks, a nonprofit that specializes in rehabilitating struggling protected areas.

Since taking over operations here, the group has confiscated upwards of 18,000 illegal snares, made over 100 arrests, installed more than 60 miles of electric fencing and removed 261 elephants to another reserve.

But African Parks also has embarked on an unusual high-tech experiment, calling in a drone team from South Africa. With funding from the World Wildlife Fund, including a $5 million grant from Google, drones are being tested here in the first systematic evaluation of their potential to combat poachers.

UAV & Drone Solutions, the company that employs Ms. Dudley and Mr. De Necker, is the first licensed drone operator in Africa, a certification that permits the company to fly drones up to 15 miles away and to operate at night — crucial advantages, given that the vast majority of poachers are active after dark and few parks are able to carry out effective nocturnal patrols.

The group now operates in South Africa, Malawi and Zimbabwe, and soon will expand to Botswana. Their fixed-wing, bespoke BatHawk drones are outfitted with cameras, video transmitters and telemetry, and with battery changes they can fly for more than eight hours.

"U.D.S. does this better by far than anyone else," said John Petersen, the board chairman of the Charles A. and Anne Morrow Lindbergh Foundation, a nonprofit. "There's no one else in the world we know of that are flying regular missions almost exclusively at night."

The idea of using drones to combat poachers is not new. Conservationists enthusiastically embraced the devices as a silver bullet a few years ago — but disappointment was swift.

Industry-grade equipment and software are needed, but they tend to be well beyond the budgets of strapped conservation organizations. Park managers opted for inappropriate models, too fragile for wild landscapes and lacking the necessary flight capabilities and cameras.

"I don't think the world of conservation has the money to spend that would be needed to make an anti-poaching drone effective," said Richard Vigne, the chief executive of Ol Pejeta Conservancy in Kenya.

Conservationists failed to do the homework needed to see if drones were actually suitable for their needs, said Nir Tenenbaum, the director of Wildeas, a conservation technology consultancy.

"So many groups want technology to solve all their problems, but usually they don't understand the tech," he said.

Government officials haven't helped. In Namibia, trial flights and training undertaken by the W.W.F., supported by the Google grant, were cut short when the government suspended the use of drones. Other nations have banned unmanned aerial vehicles entirely or have strictly limited their use.

Only recently has that begun to change. In 2015, South Africa established some of the first formal drone legislation, and other countries have started making limited exceptions for their use.

The Lindbergh Foundation's Air Shepherd program, along with the South Africa-based Peace Parks Foundation and the W.W.F.'s Google grant, have covered about half U.D.S.'s $100,000 monthly operational costs.

Despite these resources, Otto Werdmuller Von Elgg, the company's co-founder, has discovered that drones are far from the blanket solution everyone had hoped for.

"I am very convinced that we are onto something, but we're only beginning to understand how this tool can be used effectively," he said. "The challenge now is determining how we integrate drones into existing anti-poaching operations."

So far, no arrests of poachers have been made solely based on drone surveillance, and pilots have only spotted poachers a handful of times. Drone teams often don't get ground support in the form of rangers able to follow up on leads, and must frequently fly without guidance on where poachers might be, according to Mr. Werdmuller Von Elgg.

During trials in South Africa's Kruger National Park, a protected area roughly the size of Israel, "we were told to go find people in this vast area based on no intelligence — it was an absolute waste of time," Mr. Werdmuller Von Elgg said. "We were just turning batteries into noise."

When the drone team at Kruger finally did detect a group of rhino poachers, they called park officials. But officials said that there were no rangers available for deployment.

"It was very frustrating," said Ms. Dudley, who had spotted the intruders. "You get upset with people because they say they want you there and you deliver the service, but then they don't back you up."

But Otch Otto, formerly the mission area operations manager of ranger services at Kruger, believes that limited resources were better spent on proven techniques and technologies, not experimental flying drones.

"The technology is in the research phase, and to dedicate a reaction capability to something unproven does not serve the rhino," he said.

Data analysis has also been a challenge. Currently, drone operators must watch live video feed to detect intruders and it is all too easy to miss the poachers.

"It could be numerous reasons — the operator looks away for 20 seconds, or goes to grab a cup of coffeeand misses it," said Cedric Coetzee, the general manager for rhino security at Ezemvelo KwaZulu-Natal Wildlife in South Africa. "It's not going to go beep-beep-beep, and off you go. You have to spot it."

Indeed, pilots at a reserve managed by Mr. Coetzee missed a group of trespassers briefly picked up by their drone. The poachers were discovered only later in a review of the video feed.

Serge Wich, an ecologist at Liverpool John Moores University in Britain and co-founder of the nonprofit Conservation Drones, is collaborating with colleagues from the astrophysics department to develop drone software that differentiates between humans and animals.

"Once this is finalized, instead of having hours and hours of video to look at that doesn't have meaningful information, rangers will get a ping when there's a high chance that a poacher has been detected," Professor Wich said.

Perhaps the biggest challenge is that conservationists do not know how to most effectively put anti-poaching drones to use, because there have been no rigorous long-term evaluations.

South Africa's Council for Scientific and Industrial Research conducted a two-month trial with U.D.S. and concluded that the technology is "a remarkable support tool," but officials have yet to release the data supporting those findings.

Most evidence supporting drones is anecdotal: Mr. Coetzee said he has seen a significant reduction in park incursions when and where drones fly, but added that other factors could have been at play. Drones may deter trespassers, he said, but they may simply go elsewhere in the reserve.

W.W.F. plans to tease out the answers to these questions by evaluating the drones' effectiveness against poachers here in Liwonde. Trials with two Bathawks and three DJI Phantom drones began in August. The foundation also has begun a test in Zimbabwe.

Whether drones also can help reduce animals' contact with humans is also on the agenda. One unexpected discovery: DJI Phantom drones can steer elephants away from park boundaries — likely because they sound like a bit like bees, and elephants hate bees.

"At the end of the experiment, hopefully we'll be able to say here's some good things you can do with drones and here are the things you shouldn't try because they probably won't work," said George Powell, W.W.F.'s director of wildlife technology.

"We're going to do this as scientists, and hopefully we'll save some elephants in the meantime."

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Wildlife Watch

http://news.nationalgeographic.com/2016/12/wildlife-watch-china-legal-ivory-market-african-elephants/

China to Shut Down Its Ivory Trade by the End of 2017

Advocates applaud the move by the world's largest consumer of ivory, saying it could help save Africa's remaining elephants.

With African elephant populations plummeting because of poaching for the ivory trade, China's announcement that it will phase out its legal market by the end of next year comes as welcome news to advocates.

PHOTOGRAPH BY BRENT STIRTON, GETTY IMAGES, NATIONAL GEOGRAPHIC CREATIVE

By **Jani Actman**

PUBLISHED DECEMBER 30, 2016

China will shut down its domestic ivory trade by the end of 2017, according to an announcement made today by the Chinese government.

The announcement comes more than a year after China's President Xi Jinping and United States President Barack Obama pledged to enact "nearly complete bans" on the import and export of ivory, an agreement Wildlife Watch reporter Rachael Bale described as "the most significant step yet in efforts to shut down an industry that has fueled the illegal hunting of elephants."

It also follows a commitment made in October by the international community to close domestic ivory markets.

"This is the best New Year's present I've ever had," says Sue Lieberman, vice president of international policy for the Wildlife Conservation Society, a nonprofit based in New York City that works to help save elephants and other wildlife. "China is the world's largest market, both of small ivory items and high-end, expensive ones."

The global ivory trade has been banned since 1989, but during recent years large-scale poaching has resumed, and the African elephant population has dropped to as low as 415,000—a net decline of more than 110,000 from 2007. Advocates believe that legal domestic ivory markets perpetuate an illegal trade because older, pre-ban ivory can't easily be distinguished from poached ivory.

The U.S., also a significant market for elephant ivory, held up its end of the agreement with China in June when it enacted a near-total ban on the commercial trade of African elephant ivory. The new rules further limited exports and sales across state lines and restricted a hunter's allowable ivory trophy imports to no more than two a year.

China, meanwhile, has spent the past year exploring how to implement such a ban. The country convened a group of researchers from several disciplines to assess options and make recommendations to the government.

A worker finishes a piece at an ivory-carving factory in China.

PHOTOGRAPH BY BRENT STIRTON, GETTY IMAGES, NATIONAL GEOGRAPHIC CREATIVE

China now has 34 ivory manufacturers and 130 licensed retail shops that sell ivory, Wei Ji, an independent wildlife researcher, told the *Guardian* earlier this month. According to today's announcement, China will revoke some licenses by March 2017 and eventually stop all commercial ivory carving and retail sales by the end of the year. The plan to phase out the ivory trade also encourages ivory carvers to begin using other materials.

China's announcement is especially significant because Beijing controls—and has actively encouraged—its domestic ivory trade.

In 2008 the country successfully lobbied the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the body that sets global wildlife trade policy, to allow it to buy a limited amount of ivory to sell in a tightly controlled market within its borders. About that time it also built the world's largest ivory-carving factory and began opening shops to sell ivory. To further legitimize the industry, the government even added ivory carving to its official register of Intangible Cultural Heritage.

LARGEST EVER IVORY BURN DESTROYS 105 TONS

But this legal Chinese ivory trade provided a springboard for illegal trading, as Wildlife Watch reported last year:

National Geographic went inside some of China's carving factories in 2012 and revealed how China's actions were promoting the legal and illegal ivory trade. Instead of keeping prices for ivory low, the government raised them, making ivory more profitable to poachers.

Meanwhile, Beijing's plan to assign legally carved ivory products photo IDs backfired—the photos are so small that an ID used to identify a legal piece of ivory can easily be attached to an illegal one to legitimize it. The photos are so small that it's hard to tell whether the piece in the photo is the same one being sold.

Today's landmark declaration follows a pledge made by the Hong Kong government last week to phase out its domestic ivory market by 2021. Hong Kong is the world's biggest legal retail market for elephant ivory and a major transit hub for illegal ivory, much of which goes to mainland China. (Also see "Elephants Win as Hong Kong's Leader Says It Will Ban Ivory Trade.")

Lieberman says she hopes China's one-year time line for phasing out its ivory market will spur Hong Kong to shut down its market more quickly. She adds that Japan and the European Union next need to crack down on their legal ivory trades, which conservationists say are helping fuel poaching. (Related: "In Fighting Illegal Ivory, EU Lags Behind")

"The only way to save elephants is for everyone to close their markets," she says.

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