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

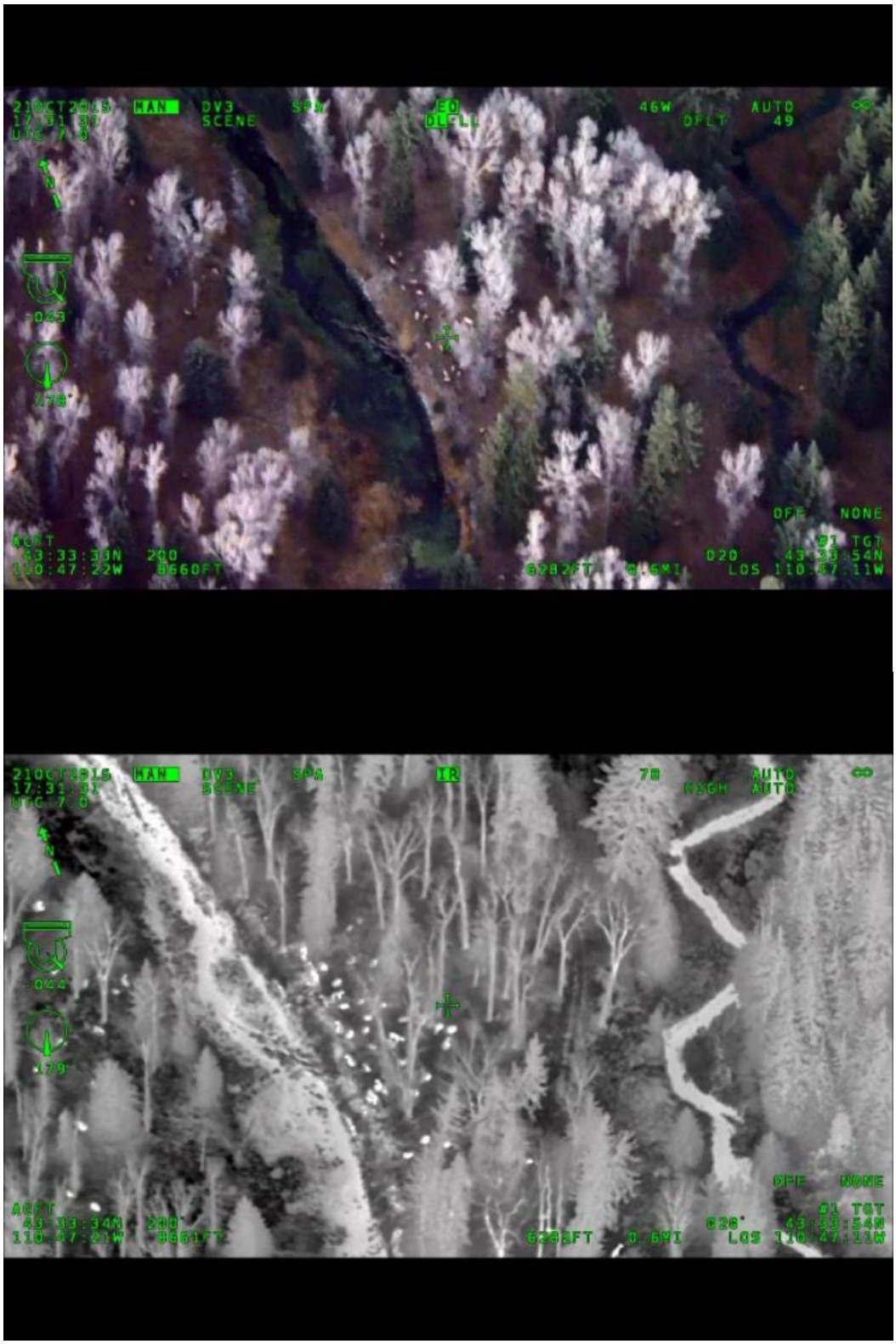
Regardless of the vehicle or platform used to employ FLIR or thermal imagery (manned or unmanned aerial), these technologies have tremendous potential to improve wildlife data collection and monitoring in the future. FLIR uses infra-red light to see through thick tree canopies or in darkness and to a 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

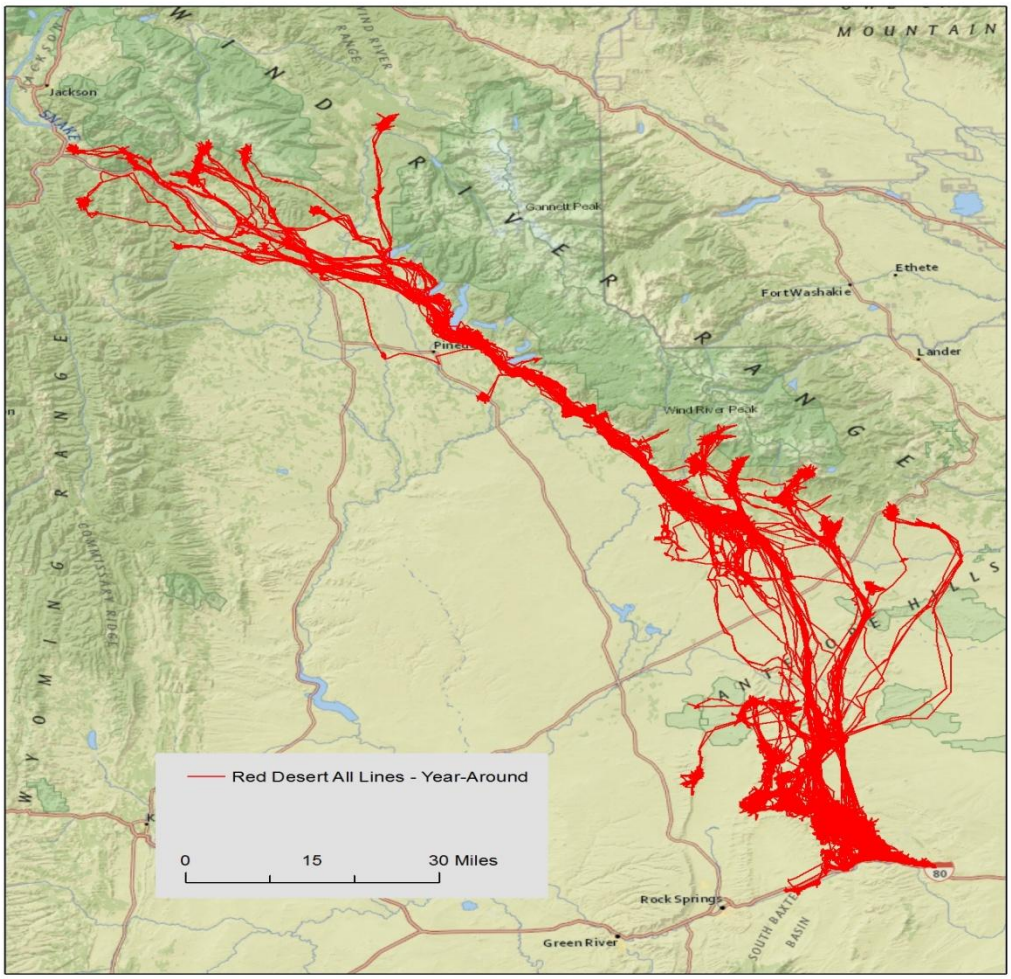
GPS Tracking

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).



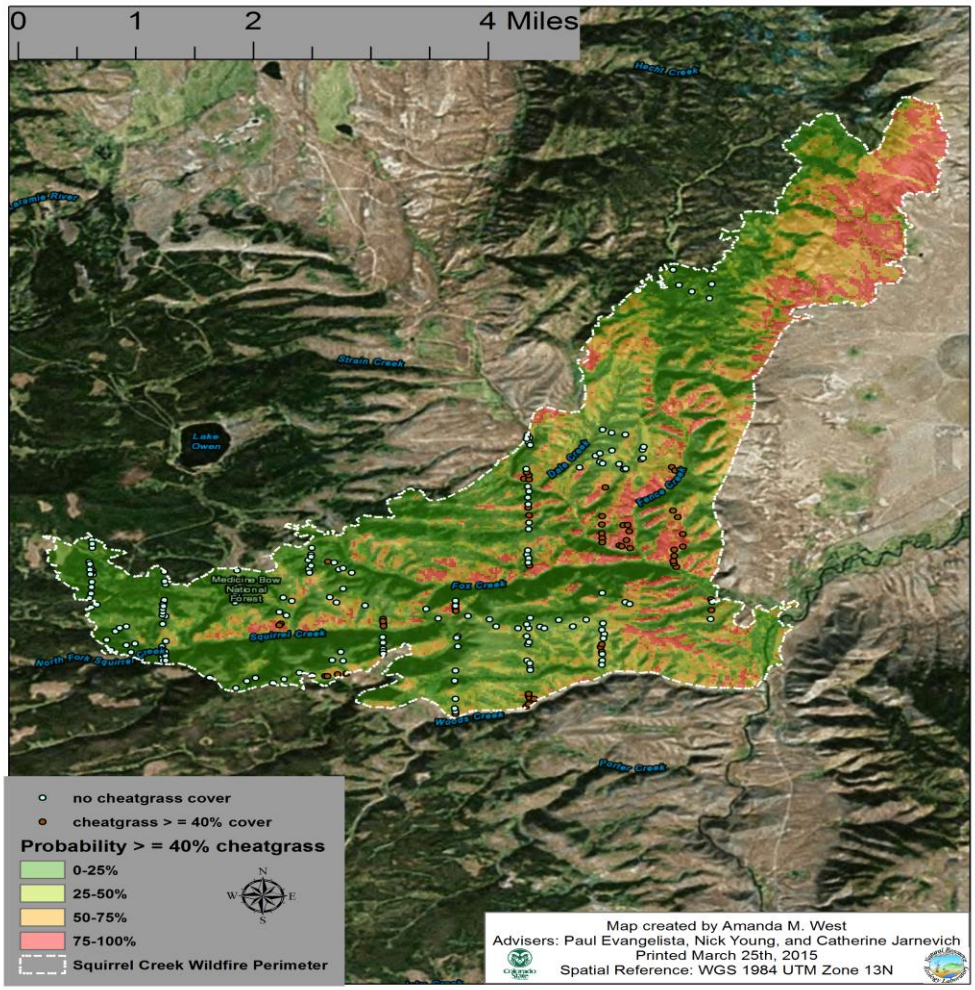
Cheatgrass (purple/red coloration) on south facing slope.

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).



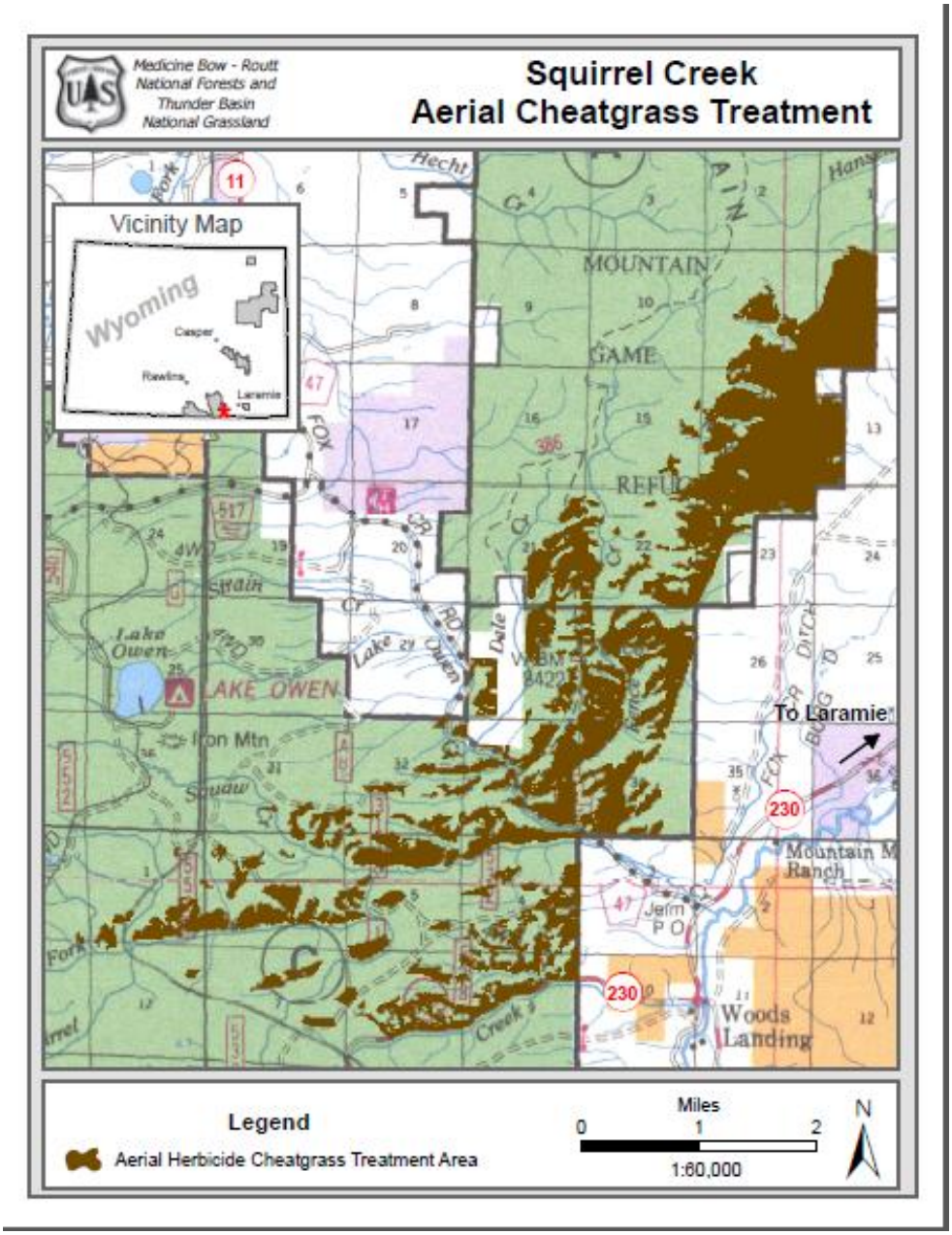
Cheatgrass probability within the Squirrel Creek wildfire burn perimeter.

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.