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MARY BURNHAM CURTIS '84

CSI Wildlife: Solving cases at world's largest wildlife crime lab

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Life and science are wild in

FORENSIC PARK

by Larry G. Anderson

Mary Burnham Curtis '84 and her colleagues at the National Fish and Wildlife Forensic Laboratory don't have a television show based on their work ... yet. But if they ever do, it could be titled *CSI Wildlife*.

Like the stars of the popular CSI television series that focuses on crimes against humans, the wildlife forensic scientists based in Ashland, Ore., investigate dead bodies washed up on shore; identify victims and perpetrators based on examination of sometimes the slimmest of physical evidence, almost routinely developing new forensic techniques in the process; assist national law enforcement officers; testify in court; and coordinate international investigations with INTERPOL and more.

They are the real deal. In fact, researchers for the TV series often contact the scientists to determine what scenarios will make their plots more realistic. For example: Is it possible to prove a victim was bitten by a bear rather than a dog?

Curtis, senior forensic scientist and head of the lab's genetics team, and 16 fellow scientists conduct their investigations at the only full-service wildlife crime laboratory in the world, and their work often seems to border on wizardry. In one case, Curtis connected illegal fishing/caviar harvesting to human criminals by recovering DNA from rocks on a river bank where white sturgeon had been dragged. When confronted with the burgeoning online illegal trade in sea turtle leather, she developed a process to extract DNA from manufactured boots to identify the protected turtle species used – a feat that was previously thought to be impossible.

"A lot of the work that Mary Curtis and her colleagues do in Ashland is not performed anywhere else in the world," says Dee Dee Hawk, director of the Wyoming Game and Fish Wildlife Forensic and Fish Health Laboratory and president of the Society for Wildlife Forensic Science (SWFS). "They are on the cutting edge of many new procedures and protocols that are then adopted by other wildlife laboratories around the world."

Like the televised CSI shows, the bad guys rarely get away. Unlike television, where CSIs deal with only the human species, wildlife forensic scientists must be able to reliably distinguish thousands of animal species that often have small differences in DNA, appearance or native range.

Wildlife forensic scientists are at the forefront of domestic and global investigative initiatives targeted at wildlife crime, and the detection, identification, and prevention of national security and public health threats.

The wildlife forensic scientists differ from their TV counterparts in another significant way. "They (CSI shows) combine three types of people: the forensic scientist, who normally is in the laboratory; crime scene investigator, who normally is a technician; and then a detective, a sworn officer who is armed and hunts down the bad guys," says Kenneth Goddard, director of the National Fish and Wildlife Forensics Laboratory. Goddard was a police crime-scene investigator for 12 years before switching to wildlife work. "The TV shows make an interesting twist in that they put the technicians in the laboratory instead, and forensic scientists in the field."

Goddard's professional background and his part-time sideline as a fiction writer make him a prime resource to sound out possible plots for the TV series and provide expert advice about wildlife forensics. If a *CSI Wildlife* show ever becomes a reality, he will insist it reflect how his colleagues really do their work.

"On any given day, I may have staff working on anything from a poaching case involving elk or deer; an illegal trade case involving violations of the Lacey Act (illegal interstate transfer of wildlife); an endangered species violation, such as sea turtle harvesting; an import/export trade violation, such as elephant ivory, rhino horn and caviar; or identifying any of the many illegal animal parts traded on the black market," Curtis says.

The prevalence of illegal wildlife trade in the United States and around the world – with an estimated value of $53 billion annually – threatens the well-being of many endangered species, but the practice is not well known among the general public. "It's everywhere, but it's like a silent crime because the only time you tend to see it is in the weird news when someone is smuggling snakes or birds taped to their body or something like that," says Laurel Neme, a wildlife conservationist and author of *Animal Investigators: How the World's First Forensics Lab is Solving Crimes and Saving Endangered Species*. "Actually, it is the third largest black market crime in the world, after drug trafficking and human trafficking."

Identifying crimes against wildlife can sometimes be even more complex than prosecuting them, based on the laws that apply to various species in various regions. For example, it's legal to possess a turkey feather, but not an owl feather. A shawl made from a cashmere goat is legal; one made from a Tibetan antelope is not. Antique elephant ivory is legal, but owning more recent ivory might not be legal, depending on when

MARY BURNHAM CURTIS '84

Major: Zoology

DePauw activities

- Little 500 women's race: rider for Lucy Rowland Hall and Delta Gamma sorority, Race Steering Committee and Race Rules chair
- Delta Gamma sorority: member, Anchor Classic Bike Race Steering Committee, sportswear chair, pledge trainer
- *The DePauw*, circulation manager

Further education

- M.S. (biology: fish ecology), University of Michigan
- Ph.D. (biology: evolutionary biology), University of Michigan

Previous positions

- Aquarist assistant, John G. Shedd Aquarium, Chicago
- Statistical technician, Unisys Corporation, Plymouth, Mich.
- Fisheries research biologist, U.S. Fish and Wildlife Service, National Fisheries Research Center – Great Lakes, Ann Arbor, Mich.
- Fisheries research biologist, National Biological Service, Great Lakes Science Center
- Research fisheries biologist, U.S. Geological Survey-Biological Resources Division, Great Lakes Science Center

Favorite DePauw memory

- "One of my favorite times was Winter Term 1983. I spent Winter Term on campus working with the late Michael Johnson [professor of zoology] on a project to identify pollen species in bee stomachs and pollen sacs. It was part science, part art and part statistics, and I had a blast working on it. I think it was that project that convinced me to pursue a research career rather than pre-med or academia."

Favorite DePauw professors

- "James Gammon [professor emeritus of biology], my major adviser, introduced me to a lifelong love of fish and fisheries; John Eigenbrodt [late professor emeritus of philosophy and religion] taught THE BEST religion course (New Testament) that I ever took; and Vic DeCarlo [professor of physics and astronomy] took the time to bring me up to the 'aha' moment when physics really began to click."

The Ashland, Ore., lab has the world's largest collection of frozen wildlife tissues.

legislation was passed and the region from which it was obtained.

The United States is considered second only to China as a top market for illicit animal products. People often don't realize they are supporting illegal wildlife trade when they purchase animal items such as products made from migratory bird feathers, native-forest rosewood for musical instruments, and religious icons, jewelry and frames made from turtle shells.

SWFS president Hawk says, "People in this country are some of the major buyers of live, imported, threatened and endangered species from around the world. Having that market available is what drives the illegal activity of poachers and traffickers in other countries."

GLOBAL SECURITY AT STAKE

A wildlife forensic scientist's first step is to determine that a crime against a protected animal has actually been committed. That's particularly crucial, for example, when criminals have tried to substitute pig, cow or even human gallbladders for the more valued bear gallbladders in the black market for animal parts that humans believe have medicinal properties. Or when lower-quality Coho salmon is substituted for higher-priced Chinook salmon. That's when Curtis' DNA analysis of species is effective. In one case, she distinguished between salmon species taken from two Alaskan rivers, the Yukon and Copper, with salmon caught legally in one river and illegally in the other.

"That's why Mary Curtis' work in particular is important," Neme says. "Smugglers are becoming more and more sophisticated, because with wildlife trade you have very high profits and fairly low risk of getting caught. For the amount of effort, what you see, especially with products such as rhino horn, tiger bone and elephant ivory, is organized networks getting more and more involved because the drug-trafficking penalties are so much higher."

Speaking at the Partnership Meeting on Wildlife Trafficking on Nov. 8, 2012 in Washington, D.C., U.S. Secretary of State Hillary Rodham Clinton noted that illegal wildlife trafficking is so lucrative that terrorist groups are getting into the business to finance their activities. "Over the past few years, wildlife trafficking has become more organized, more lucrative, more widespread and more dangerous than ever before," she said. "Many of us are here because protecting wildlife is a matter of protecting our planet's natural beauty. But it is also a national security issue, and an economic security issue that is critical to each and every country represented here."

Clinton called for the creation of a global system of regional wildlife enforcement networks to focus on illicit wildlife trade, which she said rivals the illegal arms trade in size. She pledged financial and other support from the State Department to help thwart criminal and terrorist organizations, which often use devastatingly effective modern weapons and other tools for mass slaughter of animals to harvest their parts.

The National Fish and Wildlife Forensic Laboratory and the wildlife forensic scientists will have a key role in that effort. The seriousness of their work is obvious when you arrive at the secured laboratory in the wooded mountains of southern Oregon and encounter three interconnected stone circles in front of the government building. The rings represent the three things that forensic scientists work to link together: suspect, victim and crime scene, explains Goddard, who designed the laboratory in 1986.

Their stated mission is also serious: "Wildlife forensic scientists are at the forefront of domestic and global investigative initiatives targeted at wildlife crime, and the detection, identification, and prevention of national security and public health threats."

At first glance, the National Fish and Wildlife Forensic Laboratory appears similar to a typical human CSI laboratory. It includes five units: Criminalistics (ballistics, chemistry and fingerprinting), Evidence (receipt and initial examination of materials), Genetics (DNA analysis and species origin), Morphology (species identification by features), Pathology (cause of death, natural or suspicious) and Toxicology (testing for poisons). Goddard says the lab receives evidence and cases from USFWS special agents and wildlife inspectors, all 50 state fish and game agencies, as well as many of the 177 nations that signed the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) treaty.

Stroll through the lab, and you quickly get a sense that routine is not the norm here. Pass windows of the Pathology unit, and you might see an autopsy underway on an eagle or monkey. Hallway cases display an astounding array of ways in which animal parts can be processed: soup cans, hides, feather ties, carvings, bottles of bear bile and other elixirs, boots, clothing, ivory carvings, skeletons, piles of tusks and horns. Drawers and cabinets are full of various animal parts used for analysis and comparison. Walk past sophisticated equipment such as Polymerase Chain Reaction instruments and genetic analyzers – both used in DNA sequencing – and you find the world's largest collection of frozen wildlife tissues, which are used to help identify evidence specimens from around the world.

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Or take a walk on the wild side in a separate facility dubbed Forensic Park, which is filled with a dizzying variety of stuffed exotic animals, mounted trophy heads, skeletons, animal hides, shells, bones and more accumulated over time and from various places. In addition to lab resources, Forensic Park allows the scientists to extract hairs and DNA samples for comparison with and identification of animal evidence in current cases.

NEW TECHNOLOGY, NEW TECHNIQUES

The scientists sometimes have to draw on ingenuity to find elusive evidence needed to pursue crimes against animals – or even to determine whether or not a crime has been committed. Consider the Case of the Online Boots.

Investigators monitoring animal products offered on the Internet discovered a large number of processed turtle-leather boots being auctioned on

eBay. They needed to know if the boots were made from protected turtle species or not, and that presented a problem. "Turtle skins are exposed to bleaching agents, preservation chemicals like formaldehyde and others that are enzyme inhibitors, as well as chemicals such as chromium and dyes used in the leathering process," Curtis explains. "A lot of the processing destroys the DNA or breaks it up, but there's still some in the skins.

"I set out to extract enough DNA to use Polymerase Chain Reaction (PCR), but there's a lower limit to how much DNA you need for a successful reaction; the trick is to get past the enzyme inhibitors so you can use PCR to amplify the portion of the DNA that gives you the species information. On large pieces of tanned and leathered skins, we were fairly successful in getting the DNA. It's more difficult when you have only a small amount of material to work with, such as a boot or shoe that must be returned to the owner if we determine an endangered species was not used in its manufacture."

Curtis figured out how to take a sufficient sample from crafted items in a non-destructive way. She then used extraction techniques to obtain enough DNA to be able to identify the species source of leather used to make the boots. It turned out that the boots offered for sale online were, in fact, made from the skins of endangered sea turtles, and the sellers were arrested and prosecuted.

The case also illustrates how the Internet has further increased stress on animal populations and especially endangered species. "Online trading has had a big impact on international trade in wildlife products," Curtis says. "Where you used to have to travel to a specific country to get some items, the Internet makes them available at your fingertips. Unfortunately, it also opens up people to fraud and illegal markets at the same time." The Internet also accelerates exponentially the speed at which animal species can be affected. After a cyber-rumor spread a few years ago that rhino horn could cure cancer, the number of rhinos killed worldwide tripled.

Another lab case involved bear bile, which is widely consumed for medicinal purposes by people throughout Southeast Asia and can bring as much as $1,000 a gram. The bear gallbladders from which it is made are visually indistinguishable from the same organ in other animals, especially pigs. It didn't take enterprising criminals long to discover they could buy common gallbladders from pigs and other animals and substitute them for the much pricier bear organ. The challenge was to find a way to identify specifically bile from bears in cases under investigation.

Edgard Espinoza, deputy director of the lab and vice president of the Society for Wildlife Forensic Science, developed a new chemical analysis to solve the problem. "As with all our cases, I had to collect reference materials, which in this case meant more than 20 gallbladders from bears, and I also needed them from other species that can be confused with bear," he said. "Although we're developing the technique for bear, we have to study sheep, cow and any other animal that has a gallbladder, including humans by the way, because there are records that gallbladders have been removed from human bodies for the trade."

Espinoza explains what he discovered: "In the bear world, what makes them unique is a particular structure in an amino acid. Once you know the structures, you can use chemical instruments to find that structure."

Fans of the CSI TV shows might think the bear bile/gallbladder story sounds familiar, and they'd be correct. The lab scientists explained bear bile versus pig bile and the large amounts of money involved to New York detectives investigating a real-life homicide of a criminal fraudulently selling the pig product as bear bile. When TV show researchers called, lab director Goddard suggested they do a show about the bear bile trade, and a CSI episode was born.

Human crimes occasionally cross paths with animal evidence. Wildlife forensic scientists might examine pet hairs or feathers taken from a suspect's clothing in order to tie the suspect to the scene of a homicide or other criminal activity. Or they might test suspected animal blood on a poacher's clothing, only to determine it is human blood, instead.

In one unfortunate case, two men were hunting a bear, and one of them shot it. While they tracked the wounded animal, the bear managed to come up behind one of the hunters and began to maul him, at which point the other hunter shot the bear again and killed his fellow hunter as well. "We tested the bullet and found that it had both bear and human DNA on it, which supported

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WILDLIFE FORENSICS AT WORK

A few examples:

- In the luggage of a passenger arriving at JFK airport from West Africa, inspectors find the butchered carcasses of eight monkeys – potential sources of AIDS-related diseases and other critical threats to public health.
- A U.S. Virgin Islands company is sentenced for knowingly trading in falsely labeled, protected black coral valued at more than $2.17 million.
- DNA from pet hairs provides additional evidence in a human serial murder case.
- Federal wildlife investigators disrupt a multimillion-dollar black market caviar operation directed by international organized crime syndicates.
- Wyoming Game and Fish Department breaks up a ring of poachers who killed more than 30 elk, denying hunting opportunities to licensed and ethical hunters.
- Operation Central, a 2004-10 undercover investigation of unlawful international trafficking in sea turtle parts and products, led to prison sentences for seven defendants. It remains the largest-ever probe of illegal commercial exploitation of highly endangered sea turtles.
- Terrorist groups in Africa are financing their purchases of weapons and operations by selling tusks and horns of slaughtered elephants and rhinoceroses.
- National Oceanic and Atmospheric Association (NOAA) special agents discover a half-million pounds of fraudulently labeled seafood destined for U.S. markets – a potential threat to public health and consumer confidence.
- Veterinary forensic scientists at University of California Davis assist in bringing down brutal dog-fighting rings around the country through establishment of canine DNA databases.

$53 billion
Estimated annual value of illegal traffic in protected wildlife, fisheries and timber trade, which decimates wild populations and funds illegal activities.

3,000
Pairs of turtle-leather boots examined in a single case by the National Fish and Wildlife Forensics Laboratory to determine whether they were made from legally protected species.

177
Member countries in CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

668
Rhinoceroses poached for their horns in South Africa last year.

17
Wildlife forensic scientists at the National Fish and Wildlife Forensics Laboratory in Ashland, Ore.

53,000
Samples in the National Fish and Wildlife Forensic Laboratory's collection of frozen animal tissues – the world's largest.

5
Legally protected Tibetan antelopes killed to harvest enough undercoat to make one illegal shawl.

300
Rotting walrus carcasses washed up on the Alaskan shoreline after being shot and having their heads removed for the ivory tusks.

700
Approximate number of U.S. and international wildlife crime cases investigated annually by the National Fish and Wildlife Forensics Laboratory.

RIGHT: Mary Burnham Curtis '84 in the wildlife resource area called Forensic Park.

the man's story that the bullet went through the bear and killed his buddy," Curtis says. "Sad, but at least he wasn't charged with murder."

ENSURING PROFESSIONALISM

Because of increased expectations of the relatively new field of wildlife forensics and intersections with human crimes, organized efforts are underway to establish professional standards for best practices and ethics for the wide variety of expertise the field encompasses. This is more important than ever as wildlife forensic scientists are being called upon to testify in court cases, where their scientific results must be able to stand up to the rigorous demands of trial evidence.

Deputy lab director Espinoza helped organize the Society for Wildlife Forensic Science (SWFS) in 2009, and the first meeting of leading international scientists was held at the Oregon lab. Curtis plunged headlong into its efforts in 2011 when the SWFS sponsored the Scientific Working Group for Wildlife Forensic Science (SWGWILD).

"SWGWILD is charged with developing a set of official Standards and Guidelines by which wildlife forensic science will be conducted," Curtis explains. "This includes details about evidence handling, chain of custody, reporting requirements, training requirements, etc. The intent is that laboratories doing wildlife forensic analyses will commit to following the standards, and legal entities can look to the standards as a way of evaluating the analyses they request and the credentials of their expert witnesses."

The National Academy of Sciences in 2009 published a report that was highly critical of the state of human forensic science in the United States. It focused on several high-profile cases involving misuse or misapplication of forensic analyses and perceived misconduct by some forensic labs. The process and outcome of the very public O.J. Simpson trial also spotlighted problems with forensic science. The handwriting was on the wall.

"With the additional attention being drawn to the field of forensic science," Curtis says, "it became clear that the wildlife forensic community needed to be proactive in addressing any deficiencies we saw in our field, or risk being swept up under the blanket of human forensic science."

"Mary [Curtis] is really going to be pushing the envelope on wildlife genetics. We're very much at the beginning of our area of science, and Mary is in charge of using one of the most powerful tools we have in the laboratory – DNA analysis. How she pushes that forward is going to make a huge difference in the impact of this laboratory down the road."

While wildlife forensic scientists are learning from the more established human CSI procedures and protocols, they resist having to adhere to the ill-fitting human forensics guidelines. In her area of genetics, for example, Curtis points out that human DNA forensic scientists are mainly concerned with one species (human), while wildlife forensic scientists need to be versed in many animal species – and not just genetics, but also phylogeny, taxonomy, population dynamics, behavior, ecology and more.

The need for a professional certification program was obvious. In summer 2012, Curtis became director of proficiency testing for the SWFS and took charge of wildlife proficiency testing programs for federal, state and international laboratories. Proficiency testing will be required in the certification program that SWFS will launch later this year. Curtis has also led a team of scientists to Southeast Asia and China to work with international wildlife law enforcement organizations and wildlife forensic genetics laboratories.

"Mary [Curtis] is really going to be pushing the envelope on wildlife genetics," lab director Goddard says. "We're very much at the beginning of our area of science, and Mary is in charge of using one of the most powerful tools we have in the laboratory – DNA analysis. How she pushes that forward is going to make a huge difference in the impact of this laboratory down the road."

SWGWILD chair Kathy Moore agrees. "The National Fish and Wildlife Forensic Laboratory is the largest and probably best-funded wildlife lab in the world, and one of a very few accredited wildlife labs. The Ashland lab as a whole is a great resource," she says. "They have really blazed a trail for the rest of us."

Read more about the National Fish and Wildlife Forensic Laboratory at www.lab.fws.gov.