Science and Sleuthing: Improving CITES Enforcement Through Innovations in Wildlife Forensic Technology

by Victoria Bogdan Tejeda

Victoria Bogdan Tejeda graduated from the University of California Davis School of Law in 2017 with a concentration in environmental law. Prior to law school, she consulted for environmental nonprofit organizations and co-founded the citizen science and technology group Nerds for Nature.

Law enforcement cannot, on its own, resolve the myriad of problems facing species of conservation concern. But, for some species, it is quite literally their last hope, if they are not to disappear from the face of our planet.

—John Scanlon[1]

In 1892, detective Sherlock Holmes examined evidence of "poison fangs" in a homicide investigation.[2] This was one of the first instances of wildlife evidence and scientific analysis being used in fiction.[3] The character's creator, Sir Arthur Conan Doyle, continued in subsequent novels to advocate for applying early forms of forensic science to legal matters.[4] He wrote about detectives analyzing blood residue, fingerprints, and handwriting.[5] Shortly thereafter, Dr. Edmond Locard, a real-life pioneer in the field, became known as the "Sherlock Holmes of France."[6]

Forensic science has grown substantially since that time. Now, the multidisciplinary practice—encompassing DNA mapping, spectrometer analysis, toxicology, and radiocarbon dating, among other techniques—is widely used by law enforcement and accepted in courts.[7] The United States set up its first forensic crime laboratory in 1932.[8] Adapting the science for use on wildlife crimes only came about more recently.[9] The United States' first wildlife forensic laboratory opened in 1989.[10]

Wildlife forensic science grew, in part, out of awareness that extinction loomed for thousands of plants and animals.[11] New laws, such as the Endangered Species Act (ESA) of 1973,[12] led scientists working in traditional forensic labs to investigate injuries and killings of animals.[13]

Alarm over species depletion grew around the globe as well. In 1975, 80 countries entered into the Convention on International Trade in Endangered Species of

1. Statement by John Scanlon, Secretary-General, CITES to 79th Interpol General Assembly (Nov. 8, 2010), https://cites.org/eng/news/sg/2010/SG_statement_interpol_doha.php.
2. Video: Wildlife Forensics—An Evolving Tool for Combating Wildlife Crime (World Wildlife Fund 2012) [hereinafter Wildlife Forensics—An Evolving Tool] (quoting Sir Arthur Conan Doyle, The Adventure of the Speckled Band (1892)), https://www.youtube.com/watch?v=Wu9fSMiAs6c.
3. *Id.*
4. James O'Brien, Encyclodpaedia Britannica, *Sherlock Holmes: Pioneer in Forensic Science*, https://www.britannica.com/topic/Sherlock-Holmes-Pioneer-in-Forensic-Science-1976713 (last updated Mar. 31, 2014).
5. *Id.*
6. The Forensics Library, *Edmond Locard*, http://aboutforensics.co.uk/edmond-locard/ (last visited May 12, 2017).
7. United Nations Office on Drugs and Crime, A Review of Wildlife Forensic Science and Laboratory Capacity to Support the Implementation and Enforcement of CITES 2 (2016) [hereinafter UNODC Capacity Report], *available at* https://cites.org/sites/default/files/eng/cop/17/WorkingDocs/E-CoP17-25-A4.pdf.
8. Stephanie Watson, How Stuff Works Science, *How Forensic Lab Techniques Work—History of Forensics*, http://science.howstuffworks.com/forensic-lab-technique1.htm (last visited May 12, 2017).
9. Michele Berger, *Trafficking Jam: In Wildlife CSI, Scientists Become Nature's Detectives*, Weather Channel, Feb. 6, 2015, http://stories.weather.com/animalforensics; U.S. Fish & Wildlife Service Forensics Laboratory, *Science Professionals*, https://www.fws.gov/lab/scientists.php (last updated Aug. 30, 2012). While "wildlife" generally connotes animals, when used in forensic science, it encompasses plants as well.
10. Jane E. Huffman & John R. Wallace, Wildlife Forensics: Methods and Applications 45 (1st ed. 2012).
11. Wildlife Forensics—An Evolving Tool, *supra* note 2.
12. 16 U.S.C. §§1531-1544; ELR Stat. ESA §§2-18.
13. U.S. Fish & Wildlife Service Office of Law Enforcement, *Law Enforcement Historical Background*, https://www.fws.gov/le/history.html (last updated Feb. 14, 2013). The United States hired its first biological technician to inspect wildlife shipments in 1975. U.S. Fish & Wildlife Service Office of Law Enforcement, *Law Enforcement History: 1951-1975*, https://www.fws.gov/le/history-1951-1975.html (last updated Feb. 14, 2013).

Wild Fauna and Flora (CITES).[14] It was the world's first comprehensive instrument regulating trade in endangered and threatened plants and animals.[15] Today, CITES covers 35,000 species.[16]

Under the Convention, Parties issue nearly one million import and export permits each year.[17] This number, however, does not fully capture the volume of trade, as one permit may apply to large numbers of products. CITES reported that, on average, permits in one year cover 317,000 live birds, 2 million live reptiles, 2.5 million crocodilian skins, 1.5 million lizard skins, 2.1 million snake skins, 73 tons of caviar, 1.1 million pieces of coral, and 20,000 hunting trophies.[18]

Though CITES is widely used, protected species continue to slide to extinction.[19] Two main obstacles hinder its success: (1) fraudulent paperwork, where an individual attempts to pass an endangered or threatened species as a non-protected one in order to access a legal market; and (2) illicit poaching and trafficking.[20] Wildlife forensic science can assist in addressing both.

When a prohibited species is traded in legal commercial markets, studies show criminals gain access to a broader audience than the black market alone.[21] This means it is imperative that customs and other officials inspecting CITES permits be able to distinguish one type of species from another. If there is a question, forensic science can help. Physical inspection by experts in taxonomy and morphology can assist in determining whether a product, such as a reptile-skin bag, was made from an endangered species.[22] DNA may also be used to identify a species and determine its geographic origin.[23] Both approaches reveal whether CITES permits accurately describe the goods moving in trade.

The second issue, poaching, fuels the fourth-largest black market in the world.[24] Because CITES applies only once a trade object crosses a border, the crime of poaching is largely the province of each nation's domestic laws.[25] Forensic science can play a key role, though, in identifying the contents of seized shipments.[26] For example, scientists helped bring down an international criminal network that smuggled dozens of horns from critically endangered rhinos.[27] DNA analysis of ivory can also point back to countries where poaching is a problem, thereby prompting international pressure.[28]

While forensic science has proved its centrality to CITES enforcement, substantial gaps remain in fully integrating this tool. In order for CITES to achieve its objective of protecting wildlife from overexploitation by trade, the Parties need to recognize current enforcement gaps and elevate wildlife forensic science's role, accessibility, and funding.[29] Technical and financial assistance need to be written into the Convention in order to build capacity to identify crimes. Forensic data gathered by labs and stored in reference libraries should be standardized and widely shared among Parties. Traceability could be improved, borrowing forensic tools developed by other certification regimes. This would provide supply-chain integrity in legal markets.

Part I of this Comment outlines the origins and mechanisms of CITES, and also addresses CITES' enforcement shortfalls. Part II examines the tools of wildlife forensics, current lab capacities and activities around the world, and how the science has been applied to CITES. Part III assesses gaps in how CITES utilizes forensic science, and offers various proposals to address these challenges. The Comment concludes by examining how these proposals fit together and what path may have the most impact to incorporate forensic tools into wildlife protection.

14. Convention on International Trade in Endangered Species of Wild Fauna and Flora, *adopted* Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243 [hereinafter CITES].
15. The Convention defines trade as export, re-export, import, and introduction from the sea. *Id.* art. I.
16. United Nations Office on Drugs and Crime, World Wildlife Crime Report: Trafficking in Protected Species 3 (2016) [hereinafter World Wildlife Crime Report], *available at* https://www.unodc.org/documents/data-and-analysis/wildlife/World_Wildlife_Crime_Report_2016_final.pdf; CITES, *List of Contracting Parties*, http://www.cites.org/eng/disc/parties/alphabet.shtml (last visited May 12, 2017).
17. World Wildlife Crime Report, *supra* note 16, at 10.
18. TRAFFIC, *Wildlife Trade: What Is It?*, http://www.traffic.org/trade/ (last visited May 12, 2017).
19. For example, in one year, CITES-registered ivory trade accounts for only around 20% of the total estimated world ivory movement of 771 tons. 54 Fed. Reg. 24760 (June 9, 1989).
20. CITES, *What Is CITES?*, https://www.cites.org/eng/disc/what.php (last visited May 12, 2017); *see also* World Wildlife Crime Report, *supra* note 16, at 10.
21. World Wildlife Crime Report, *supra* note 16, at 10.
22. United States v. One Handbag of Crocodilus Species, 856 F. Supp. 128, 131 (E.D.N.Y. 1994).
23. Trace Network, Current Wildlife Forensics Tests (May 2012), http://www.tracenetwork.org/wp-content/uploads/2012/08/3-Current-wildlife-forensic-tests-May-2012.pdf.
24. Tom Milliken, USAID & TRAFFIC, Illegal Trade in Ivory and Rhino Horn 1 (2014), *available at* http://www.traffic.org/storage/W-TRAPS-Elephant-Rhino-report.pdf.
25. World Wildlife Crime Report, *supra* note 16, at 11.
26. Note that CITES forbids legal trade if the specimen was obtained in "contravention of the laws of the State." *See* CITES art. III(2)(b), art. IV(2)(b), art. V(2)(a).
27. Murray Carpenter, *The Key to Some Big Endangered Species Crime Investigations Is a Small Lab in Oregon*, PRI's The World, Aug. 6, 2014, http://www.pri.org/stories/2014-08-06/key-some-major-endangered-species-crime-investigators-small-lab-oregon.
28. Liz Rasheed, *Is CITES Endangered?*, Geo. Envtl. L. Rev., Nov. 23, 2015.
29. The preamble of CITES states that "international cooperation is essential for the protection of certain species . . . against over-exploitation through international trade." While CITES may not directly impact poaching, if supported by forensic science, it can play a powerful role in deterring and holding such criminals accountable.

I. CITES: Global Wildlife Trade Regulation

Global trade has long threatened plant and animal species. During the 1930s, the United States alone consumed 200 tons of ivory per year for use in consumer goods such as combs and billiard balls.[30] A notable birder in 1886, alarmed at the trend to fasten wild bird feathers onto hats, counted the number of species he observed on passing women in New York City one afternoon. He identified wings, heads, tails, and entire bodies of 174 birds covering 40 species.[31]

In the 1960s, recognition grew among governments that trade was putting many plants and animals on the path to extinction.[32] While domestic laws could constrain trade within a country's borders, international import and export lacked regulation.[33]

A. *CITES Formation and Structure*

In 1963, a number of countries meeting for the International Union for the Conservation of Nature passed a resolution calling for "an international convention on regulations of export, transit and import of rare or threatened wildlife" and their parts.[34] After a decade of subsequent draft proposals and negotiations, in 1973, 80 countries signed the Convention.[35]

CITES is the foremost international law tool for regulating trade in endangered and threatened wildlife.[36] Today, CITES governs trade in more than 35,000 plant and animal species among 183 signatory Parties.[37] Under the Convention, nearly one million permits for legal shipments of protected wildlife products are issued each year.[38]

CITES focuses on traceability, defined as the tracking of an item's origins, distribution, and use.[39] To achieve this, CITES regulates how listed species and their parts (collectively called "specimens") are exported, imported, and used.[40] The level of protection each species receives depends on how it is categorized within the Convention's three-tiered appendix framework.[41]

Appendix I provides the highest level of protection. Species listed in this section are those "threatened with extinction" and "which are or may be affected by trade."[42] Permits are required for both export and import of Appendix I species.[43] To obtain a permit, a scientific authority from both the importing and exporting Parties must verify that trade will not be "detrimental to the survival of that species."[44] The importer is also prohibited from using a specimen for commercial purposes.[45]

Appendix II regulates species "which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation."[46] In contrast to Appendix I, import is allowed for commercial purposes. Otherwise, trade in Appendix II species is subject to similar permit requirements as Appendix I.[47] A scientific authority in the exporting country must also confirm that export will not be detrimental to survival.[48]

Appendix III provides the least protection. States unilaterally designate species under this section in order to avoid exploitation or to secure cooperation of other countries in controlling trade in those species.[49] While export and import permits are required if both trading states list the species under Appendix III, only a certificate of origin is required for import into other countries.[50] Appendix III does not require an opinion by a scientific authority regarding the impact of trade on the species.

Under CITES, noncompliance with the Convention must first be reported to the secretariat.[51] The secretariat then relays this information to the offending Party, who must then propose remedial action.[52]

CITES does not prescribe remedial measures. Rather, the decision on how to enforce and penalize violations is left up to each Party's domestic laws. The Convention only provides that Parties ought to take "appropriate measures" to enforce the treaty and "prohibit trade in specimens in violation thereof."[53] Measures may include penalties and confiscation of specimens.[54] CITES does not require violations to be deemed a crime.[55]

B. *CITES Enforcement Shortfalls*

While CITES regulates trade in tens of thousands of species, overexploitation and decimation of endangered and

30. National Geographic, *The History of the Ivory Trade*, http://nationalgeographic.org/media/history-ivory-trade/ (last visited May 12, 2017).
31. *The Feather Trade and the Formation of the Audubon Society*, Farsnworth Art Museum, Mar. 23, 2010, http://www.farnsworthmuseum.org/blog-entry/feather-trade-and-formation-audubon-society.
32. World Wildlife Fund, *CITES*, http://www.worldwildlife.org/pages/cites (last visited May 12, 2017).
33. *Id.*
34. Willem Wijnstekers, International Council for Game and Wildlife Conservation, The Evolution of CITES 31 (9th ed. 2011), *available at* https://portals.iucn.org/library/sites/library/files/documents/CITES-012-2011.pdf.
35. *What Is CITES?*, *supra* note 20.
36. Rasheed, *supra* note 28.
37. World Wildlife Crime Report, *supra* note 16; *List of Contracting Parties*, *supra* note 16.
38. World Wildlife Crime Report, *supra* note 16, at 10.
39. United Nations Global Compact, A Guide to Traceability 6 (2014) [hereinafter Guide to Traceability], *available at* https://www.bsr.org/reports/BSR_UNGC_Guide_to_Traceability.pdf.
40. *See* CITES art. II; *see also* art. I(b)(i) (defining "specimen" as "any animal or plant, whether alive or dead, [and] any readily recognizable part or derivative").
41. CITES art. II.
42. *Id.* art. II(1).
43. *Id.* art. III(2), (3).
44. *Id.* art. III(2)(a), (3)(a).
45. *Id.*
46. *Id.* art. II(2)(a).
47. *Id.* art. IV(2), (4).
48. *Id.* art. IV(2)(a).
49. *Id.* art. II(3).
50. *Id.* art. V(2), (3).
51. *Id.* art. XIII(1).
52. *Id.* art. XIII(1), (2).
53. *Id.* art. VIII(1).
54. *Id.* art. VIII(1)(a)-(b).
55. World Wildlife Crime Report, *supra* note 16, at 23.

threatened wildlife persist.[56] Much of this is due to illegal poaching and organized crime.[57] Some of the problems may be addressed within the CITES regime, while others are solely the province of individual state actors.[58]

Statistics revealing CITES' shortcomings can be staggering. When Tanzania joined CITES in the 1970s, its Selous Game Reserve contained 100,000 elephants.[59] In 2013, the elephants in the reserve numbered only 13,000.[60] In 2013, a study revealed that Africa's forest elephant population had dropped 62% over just 10 years.[61]

The problem goes beyond elephants. Between 1999 and 2015, officials confiscated nearly 7,000 threatened or endangered species in illicit global shipments.[62] Illegal trade in tiger skins and other body parts contributed to the animal's decline from around 100,000 in the early 1900s to around only 3,200 today.[63] Between 2007 and 2013, 1,500 pangolins were legally traded under CITES, while officials seized more than 100,000 in illegal traffic.[64] The price for illicit goods can be staggering, providing high incentives to avoid CITES regulations. A one-kilogram piece of agarwood used in perfumes and traditional Chinese medicine sold for $3 million in 2015.[65]

The burden is distributed widely across different countries and species. No one plant or animal makes up more than 6% of all wildlife trade crimes.[66] No one country is the source of more than 15% of the total number of seized shipments.[67] Traffickers caught between 1999 and 2015 came from 80 different countries.[68] Wildlife trafficking is now the fourth-largest illegal trade in the world.[69] Its proceeds fuel organized crime, illicit drug and arms trade, and sometimes terrorist activities.[70]

Exacerbating this issue is the fact that many endangered species subject to poaching and illegal trade originate in developing countries.[71] These countries "are less likely to take action to comply with CITES or any other international treaty due to the competing interests of their citizens for resources."[72]

Meanwhile, cryptocurrencies like Bitcoin and online marketplaces provide tools to request and obtain illicit plants and animals. One study found that online advertisements for CITES Appendix I species (receiving the highest level of protection) in China increased 279% between 2008 and 2014, coinciding with the rise of unregulated transactional tools.[73]

CITES Parties and leaders recognize these enforcement shortcomings. In 2008, the Parties adopted a strategic vision identifying three goals, including improved enforcement of the Convention.[74] In 2010, Secretary-General John Scanlon stated that CITES Members take enforcement "extremely seriously" and would pursue actions to improve capacity, technical support, and international agency coordination.[75] Scanlon also announced the launch of the International Consortium on Combating Wildlife Crime (ICCWC).[76]

The ICCWC coordinates the CITES secretariat, INTERPOL, the United Nations Office on Drugs and Crime (UNODC), the World Bank, and the World Customs Organization with a goal of supporting national and regional wildlife enforcement.[77] In the mid- to longer term, ICCWC plans to provide institutional support, build capacity of enforcement organizations, and foster coordinated enforcement actions.[78]

While these efforts are laudable and important, they largely address what happens *after* discovery of a violation. The linchpin issue in CITES enforcement comes before that step: identifying plants and animals moving in illegal trade.

Port-of-entry customs officials discover most of the world's illegal wildlife trafficking.[79] While it may be easy to determine that a shipment lacks a permit, other—and common—scenarios where individuals seek to avoid CITES altogether are more challenging. For example, how can officials identify a species if the requisite identifying mark is falsified, or not present at

56. *Id.*
57. *Id.*; *see also* International Consortium on Combating Wildlife Crime, ICCWC Indicator Framework for Combating Wildlife and Forest Crime 3 (2016) [hereinafter Indicator Framework], *available at* https://cites.org/sites/default/files/eng/prog/iccwc/E-ICCWC-Ind-FW-Assessment_guidelines_and_template.pdf.
58. World Wildlife Crime Report, *supra* note 16, at 11.
59. Rasheed, *supra* note 28.
60. *Id.*
61. Fiona Maisels et al., *Devastating Decline of Forest Elephants in Central Africa*, 8 PLoS ONE e59469 (2013), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0059469.
62. World Wildlife Crime Report, *supra* note 16, at 13.
63. Scanlon, *supra* note 1.
64. World Wildlife Crime Report, *supra* note 16, at 17.
65. Press Release, United Nations Environment Programme, First-Ever World Wildlife Day Spotlights Far-Reaching Impact of US$19 Billion Illicit Trade in Flora and Fauna (Mar. 3, 2014), *available at* http://www.unep.org/newscentre/first-ever-world-wildlife-day-spotlights-far-reaching-impact-us19-billion-illicit-trade-flora-and.
66. World Wildlife Crime Report, *supra* note 16, at 14.
67. *Id.*
68. *Id.*
69. Aisling Irwin, *How Forensic Science Can Stop Slaughter of Endangered Wildlife*, New Scientist, Sept. 13, 2016, https://www.newscientist.com/article/2105629-how-forensic-science-can-stop-slaughter-of-endangered-wildlife/.
70. Scientific Working Group for Wildlife Forensic Science, Providing Essential Standardization for the Scientific Analysis of Evidence in Cases Involving Wild and Domesticated Fauna and Flora 3 (2012) [hereinafter SWGWILD Report], *available at* http://www.wildlifeforensicscience.org/wp-content/uploads/2016/07/swgwild_white_paper_011012.pdf.
71. World Wildlife Crime Report, *supra* note 16, at 24.
72. 3 Law of Environmental Protection §21:66 (2017).
73. Rasheed, *supra* note 28.
74. *CITES Strategic Vision: 2008-2013*, CITES, COP16 Doc. 12 (2008).
75. One step, effective immediately, was the elimination of a staff position housed within the secretariat in order to hire an enforcement support officer. Scanlon, *supra* note 1.
76. *Id.*
77. *Id.*; *see also* CITES, *What Is ICCWC?*, https://cites.org/eng/prog/iccwc.php (last visited May 12, 2017).
78. CITES, *ICCWC Strategic Programme 2016-2020*, https://cites.org/prog/iccwc.php/Strategy (last visited May 12, 2017).
79. World Wildlife Crime Report, *supra* note 16, at 10. *See also* Scanlon, *supra* note 1 ("Many of the national bodies around the world, especially in the developing world, which are tasked with wildlife law enforcement, are not police agencies. Instead, they may be national parks departments, ministries of forestry, fishery protection agencies, or wildlife authorities.").

all?[80] What if traffickers claim their specimens are merely synthetic impostors or from species not protected under the treaty?[81] Once a species is killed and its parts separated into products, what chance do customs and other enforcement officials have of identifying the geographic and biological source?[82] Given these obstacles, how can CITES be reasonably enforced in such a way as to punish wrongdoers and deter other traffickers?

It is here that the science of wildlife forensics may be useful. The science has been used for decades to support CITES enforcement. Yet, its distribution and use is uneven. Wildlife forensic science must be bolstered, shared, and standardized around the globe.

II. Wildlife Forensic Science

A. Overview

Forensics is the application of various scientific subdisciplines to investigate and generate evidence in relation to legal proceedings.[83] "Forensic" refers to the purpose of the chosen method and the way in which it is performed.[84] Each aspect of the analysis must be validated, documented, and able to withstand legal scrutiny.[85] All crime labs, whether analyzing evidence from humans or wildlife, seek to identify evidence and link the suspect to the victim and crime scene.[86]

Similarly, wildlife forensics is the application of various disciplines, but to plant and animal criminal investigations. The practice draws on genetics, morphology, chemistry, pathology, and veterinary sciences.[87] Scientists use tools like comparison microscopes, mass spectrographs, morphology, 3D scanners, and DNA analysis.[88]

Genetic testing using DNA is critical when evaluating CITES violations.[89] Nearly "any species to which an animal belongs can be genetically characterized to a high degree of certainty" using DNA forensic and identity testing.[90] Using genetics, scientists can determine a sample's taxonomic family, species, subspecies, population origin, individual origin, gender origin, and parentage of questioned evidence.[91] Once this information is determined, enforcement authorities may determine whether a suspect illegally poached and trafficked a species regulated under CITES.[92]

The "never-ending" wildlife forensics research problem is that scientists must develop and verify new protocols to link wildlife parts and products back to a specific source, "knowing full well that they could have come from anywhere on the planet."[93] Complicating this pursuit is that it may be legal to kill or capture certain animals depending on the species, date of the kill or capture, place of origin, type of weapon used, or possession of a valid hunting license.[94] Wildlife forensic scientists often do not receive the entire animal or plant, and instead may be called to assess a leather good, piece of wood, or other decorative item that no longer resembles its source material.[95] These factors make forensic science all the more imperative to determining whether a crime took place.

The U.S. Fish and Wildlife Service's (FWS') National Fish and Wildlife Forensics Laboratory in Ashland, Oregon, is the official forensic research facility for CITES.[96] The lab may receive samples from across the United States and all CITES Member countries.[97] International wildlife forensic labs around the globe—such as those in Malaysia, Thailand, Vietnam, and Europe—also provide critical enforcement support.[98]

The FWS lab employs just over a dozen forensic scientists organized into morphology, genetics, pathology, chemistry, and criminalistics teams.[99] The teams typically process 1,000 cases each year involving 15,000 separate pieces of evidence.[100] DNA analysts at the Ashland lab "are experts in the phylogenetic evolution, taxonomy, and biogeography of more than 150 mammal, bird, reptile and amphibian species."[101] The lab boasts that it can obtain and successfully analyze DNA from plant and animal products such as "kiln dried wood, tanned leathers, pasteurized sturgeon caviars, antler, bone and ivory."[102]

B. Forensic Science Applied to CITES

Wildlife forensics, while not explicitly mentioned by CITES, for decades has supported identifying and proving violations of the Convention.[103] The Conference of the Parties (COP) and Standing Committee are also increas-

80. CITES art. VI(7) (allowing a Party's management authority to affix a mark onto a specimen).
81. The CITES database contains more than 100 cases of attempted trade in Siamese rosewood based on fraudulent paperwork. World Wildlife Crime Report, *supra* note 16, at 19.
82. Berger, *supra* note 9.
83. *Science Professionals*, *supra* note 9.
84. UNODC Capacity Report, *supra* note 7.
85. *Id.*
86. Wildlife Forensics—An Evolving Tool, *supra* note 2.
87. UNODC Capacity Report, *supra* note 7, at 3. For example, scientists observed the timing of blowflies hatching out of two dead bear cubs to tie suspects to the crime. Kim Todd, *Bear Market*, Legal Aff., Nov./Dec. 2002, at 54.
88. Wildlife Forensics—An Evolving Tool, *supra* note 2; *see also* SWGWILD Report, *supra* note 70, at 3.
89. World Wildlife Crime Report, *supra* note 16 (Use of DNA analysis "can yield penetrating insights into wildlife crime.").
90. Bruce Budowle et al., *Recommendations for Animal DNA Forensic and Identity Testing*, 119 Int'l J. Legal Med. 295 (2005), *available at* https://www.fws.gov/lab/pdfs/Budowle_etal2005.pdf.
91. *Science Professionals*, *supra* note 9.
92. UNODC Capacity Report, *supra* note 7, at 6.
93. Wildlife Forensics—An Evolving Tool, *supra* note 2.
94. *Id.*
95. *Id.*
96. *Id.*
97. *Id.* It regularly sees samples from only around six Parties. Berger, *supra* note 9.
98. UNODC Capacity Report, *supra* note 7, at 27.
99. Wildlife Forensics—An Evolving Tool, *supra* note 2.
100. Berger, *supra* note 9. One researcher recalled receiving 3,000 pairs of shoes for one case. The lab determined that the species used, mostly a type of sea turtle and alligator, were done so in violation of CITES. *Id.*
101. *Id.*
102. *Id.*
103. Bruce Zagaris, *CITES Meeting Focuses on Strategic Vision and Enforcement*, 29 Int'l Enforcement L. Rep. 144 (2013).

ingly adopting resolutions, decisions, and recommendations aimed at bolstering the role of forensic science in CITES enforcement.[104] In 2013, Parties approved a resolution aimed at increasing forensic testing of seized or stockpiled rhino and elephant parts.[105] At the 2016 COP, a resolution encouraged Parties and organizations to "promote and increase the use of forensic technology" in criminal investigations.[106]

A common way to evade CITES regulation is to claim a product is from a similar-looking, non-protected species.[107] Listing an incorrect species on a CITES certificate is a violation.[108] Forensic science is a proven response for addressing such challenges.[109]

For example, in *United States v. One Handbag of Crocodilus Species*,[110] a company attempted to import skins from an endangered crocodile species. Customs officials in the United States determined the traffickers were using fraudulent CITES certificates in claiming that the skins originated from a non-endangered reptile.[111] Forensic analysis revealed that the crocodile products came from a protected species.[112] This information together supported a finding that the traffickers violated the treaty.[113]

African elephants are listed in CITES under either Appendix I or II, depending on their country of residence.[114] This means some trade in ivory is legal.[115] While it is "nearly impossible" to determine visually whether a carved piece of ivory came from a poached or properly permitted source, forensic analysis can aid in the distinction.[116] For example, DNA analysis of ivory seized in Asia is often traced back to the Selous Game Reserve in Tanzania.[117] In that reserve, elephants are fully protected under Appendix I, but nearly 66% of the park's elephants have been killed between 2009 and 2013.[118]

Because of these and other examples, wildlife forensic science's role in CITES enforcement is gaining recognition. In 2012, the ICCWC released the Wildlife and Forest Crime Analytic Toolkit.[119] The document "helps to analyze a country's preventative and criminal justice responses to wildlife and forest crime" by identifying technical and capacity needs.[120] While not all of the toolkit's recommendations touch on wildlife forensic science, both the toolkit and the ICCWC's accompanying "Indicator Framework for Combating Wildlife and Forest Crime recognize forensic science as an integral enforcement tool."[121] Further, in "support of the deployment of forensic technology," the ICCWC issued guidance specific to ivory and timber.[122] These documents seek to reach a broad array of CITES enforcers, including "first responders, investigators, law enforcement officials, forensic scientists, prosecutors and the judiciary."[123]

In September 2016, CITES announced the launch of IvoryID, the "world's largest ivory database."[124] CITES Parties can now access 700 reference samples from 30 countries compiled using "state of the art forensic techniques" such as isotope fingerprinting.[125] The database allows users to differentiate between legal and illegal ivory.[126] This effort followed a 2010 CITES resolution calling for Parties to "cooperate in the development of techniques to enhance the traceability of elephant specimens in trade," through such actions as supplying samples for forensic research and facilitating ways to share DNA data.[127] The database is open-access, free of charge, and includes information about the methods of identification so that "certified laboratories" may apply the techniques.[128]

Even with these achievements, there is a long way to go before forensic science supports CITES enforcement to its full potential.

III. Forensic Science and CITES Enforcement: Shortfalls and Proposals

The UNODC surveyed 110 labs with wildlife forensic capabilities in 39 countries.[129] The 2015 report identifies gaps and puts forth recommendations for improving the field in order to support CITES enforcement specifically.[130] The gaps named by the United Nations fall into three general categories: (1) quality control; (2) capacity;

104. UNODC Capacity Report, *supra* note 7, at 7.
105. Russell McLendon, *5 Big Breakthroughs at CITES 2013*, Mother Nature Network, Mar. 20, 2013, http://www.mnn.com/earth-matters/animals/blogs/5-big-breakthroughs-at-cites-2013.
106. *Timber Identification*, CITES, COP17 Doc. 48.1 (2016), https://cites.org/sites/default/files/eng/cop/17/WorkingDocs/E-CoP17-48-01.pdf. Another timber identification resolution mentions forensic analysis 38 times and discussed the key role forensics can play in CITES enforcement. *Development of Timber Identification Guidance*, CITES, PC22 Doc. 14.2 (2016), https://cites.org/sites/default/files/eng/com/pc/22/E-PC22-14-02-R1.pdf.
107. World Wildlife Crime Report, *supra* note 16, at 96.
108. United States v. 1,000 Raw Skins of Caiman Crocodilus Yacare, No. CV-88-3476, 1991 WL 41774, at *4 (E.D.N.Y. Mar. 14, 1991).
109. UNODC Capacity Report, *supra* note 7, at 3, 8.
110. 856 F. Supp. 128, 131 (E.D.N.Y. 1994).
111. UNODC Capacity Report, *supra* note 7, at 3, 8.
112. *Id.*
113. *Id.*
114. Matt McGrath, *Efforts to Boost Elephant Protection Fails at CITES*, BBC News, Oct. 3, 2016, http://www.bbc.com/news/science-environment-37541378.
115. FWS, CITES & Elephants (2013), *available at* https://www.fws.gov/le/pdf/CITES-and-Elephant-Conservation.pdf.
116. Michael J. Glennon, *Has International Law Failed the Elephant?*, 84 Am. J. Int'l L. 1 (1990).
117. Rasheed, *supra* note 28.
118. *Id.*
119. CITES, *Tools: The Wildlife and Forest Crime Analytic Toolkit* [hereinafter CITES, *Tools*], https://cites.org/eng/prog/iccwc.php/Tools (last visited May 12, 2017).
120. UNODC, Wildlife and Forest Crime: The ICCWC Wildlife and Forest Crime Analytic Toolkit, *available at* https://cites.org/sites/default/files/eng/prog/iccwc/Toolkit_Fact_Sheet_ENG.pdf.
121. Indicator Framework, *supra* note 57.
122. CITES, *Tools*, *supra* note 119.
123. *Id.*
124. *See* Stefan Jungcurt, *IvoryID Database Enables Ivory Tracing*, SDG Knowledge Hub, Sept. 28, 2016, http://sdg.iisd.org/news/ivoryid-database-enables-ivory-tracing.
125. Press Release, CITES, World's Largest Ivory Database Now Available to CITES Parties (Sept. 23, 2016), *available at* https://cites.org/eng/news/pr/Worlds_largest_ivory_database_now_available_to_CITES_Parties_23092016; IvoryID, *What Happened*, https://ivoryid.org/en/pages/about/how_it_all_began (last visited May 12, 2017).
126. Jungcurt, *supra* note 124.
127. *Trade in Elephant Specimens*, CITES, Resolution Conf. 10.10 (Rev.COP16).
128. Jungcurt, *supra* note 124.
129. UNODC Capacity Report, *supra* note 7, at i.
130. *Id.* at 6.

and (3) data availability and standardization. To this list I would also add supply-chain traceability.

Fortunately, a number of possible solutions exist to address each of these shortfalls. Some solutions are already underway, while others have just recently been proposed. In most instances, the possible solutions would be less effective in isolation. If CITES Parties truly want to improve the Convention's enforcement, these solutions should be pursued in tandem.

A. Quality Control

Problem Description: The FWS lab in Ashland, Oregon, underwent a "grueling" week-long facility inspection in 1997 in order to obtain accreditation from the American Society of Crime Lab Directors/Laboratory Accreditation Board.[131] The accreditation assures that the lab's analytical and safety protocols, case and evidence management systems, and equipment meet forensic industry standards common among "police-type" labs throughout the United States.[132] Different accreditations exist in different countries, though, if at all.[133] Dee Dee Hawk, Director of Wyoming's Wildlife Forensic and Fish Health Lab and board member of the Society for Wildlife Forensic Science, noted, "When you go into a human forensics lab, everyone is doing the exact same test in the exact same way. They have kits for everything. . . . [Meanwhile] there's not a lot of standardization in wildlife forensics."[134]

According to the UNODC report, few wildlife forensic labs operate in full accordance with "recognized best practices."[135] The study found that fewer than one-half (44%) of the 110 labs surveyed operate under a quality assurance standard.[136] Among the 74 labs that conducted CITES casework in the past six years, 30 could not identify any standard under which they operated.[137]

Against these inconsistencies, the reliability of results from various labs is questionable.[138] Results must be able to withstand legal scrutiny.[139] The variations between labs also make it difficult for law enforcement to select a suitable laboratory.[140]

Possible Solutions: To improve the reliability, consistency, and legal quality of forensic evidence, CITES Parties should support existing efforts to "democratize" certification and accreditation. This support could come in the form of endorsements through resolutions, as well as financial and logistical assistance.

One group took a first step toward this goal. In 2012, the Scientific Working Group for Wildlife Forensic Science (SWGWILD) launched a low-cost, freely accessible laboratory "proficiency test" program modeled on established accreditation standards.[141] SWGWILD no longer exists, and the Ashland wildlife forensic laboratory assumed the duties of assembling, distributing, collecting, and evaluating proficiency test samples.[142] While this standard is not yet widespread or endorsed by CITES, the open-access nature of the program provides a stepping stone for labs to attain quality standards.

In addition to accreditation, there is certification. Certifying individual lab technicians would both address lab-to-lab variations and allow existing labs working mainly with human evidence to also conduct wildlife investigations.[143]

Several efforts promoting and offering certification are already underway, such as SWGWILD's practitioner certification program.[144] As of 2015, 24 people completed the requirements.[145] Several countries have approached the Society about making certification mandatory for their wildlife forensic scientists.[146] CITES Parties should support this suggestion.

Funding and accessibility pose barriers to any quality control improvement. Applicants to the SWGWILD programs pay a fee ranging from $250-$300.[147] While this amount is not tremendous, CITES Parties ought to consider how to build the capacity of forensic scientists and technicians in the face of growing plant and animal threats.

Certification also requires certain higher education and casework experience.[148] CITES might benefit from offering education exchanges, for example, where promising scientists in developing countries are given the chance to study for free or at low cost at an institution where forensic labs exist.

It is also risky to rely on the Ashland facility to conduct proficiency and certification tests in addition to its regular casework. Particularly with the Republican administration that began in 2017, funding for federal programs is not guaranteed.[149] CITES Parties can build on this model and

131. FWS Forensics Laboratory, *About the Laboratory: Our Lab's Timeline*, https://www.fws.gov/lab/timeline.php (last updated July 6, 2015).
132. *Id.*
133. UNODC Capacity Report, *supra* note 7, at i, 26-27.
134. Berger, *supra* note 9.
135. UNODC Capacity Report, *supra* note 7, at i, 26-27.
136. *Id.* at 21.
137. *Id.* at 23.
138. Society for Wildlife Forensic Science, *Wildlife Forensic Resources—Groups and Work Products* (noting that as a branch of forensic science, it is essential that wildlife forensic casework is performed to recognized standards that meet the criteria for generating evidence that is admissible in court), http://www.wildlifeforensicscience.org/documents/ (last visited May 12, 2017).
139. Budowle et al., *supra* note 90, at 296.
140. UNODC Capacity Report, *supra* note 7, at 5.
141. SWGWILD Report, *supra* note 70.
142. SWGWILD, Wildlife Proficiency Test Program 3 (2015), *available at* http://www.wildlifeforensicscience.org/wp-content/uploads/2011/11/WPT-Charter-2015.pdf.
143. National Voluntary Laboratory Accreditation Program, *Accreditation vs. Certification*, https://www.nist.gov/national-voluntary-laboratory-accreditation-program-nvlap/accreditation-vs-certification (last updated Jan. 24, 2017).
144. SWGWILD, *Become Certified as a Wildlife Forensic Scientist*, http://www.wildlifeforensicscience.org/become-certified/ (last visited May 12, 2017). In 2014, the University of Florida began the country's first Wildlife Forensic Sciences online certificate and continuing education program. Berger, *supra* note 9.
145. Berger, *supra* note 9.
146. *Id.*
147. *Become Certified as a Wildlife Forensic Scientist*, *supra* note 144.
148. *Id.*
149. The lab also periodically conducts trainings for wildlife rangers abroad. In 2011, U.S. staff trained 30 rangers from six African countries in evidence-gathering and documentation. Wildlife Forensics—An Evolving Tool, *supra* note 2.

offer funding in order to maintain this program, or spread the burden to other labs around the world already meeting quality assurance and evidence analysis standards. A resolution requiring a guilty importer, carrier, or both to pay into a fund to develop this type of capacity may also be useful.[150]

Ensuring standards continue to be met is also necessary. This requires monitoring and enforcement. Fair Trade USA, for example, requires periodic monitoring, which can be expensive.[151] Once a technician is certified, SWGWILD does not audit technicians to ensure they continue to meet best practices. If CITES Parties want to strengthen the quality of forensic evidence, they would be wise to require monitoring and enforcement of labs and practices.

B. Capacity

Problem Description: Many CITES Member countries do not have their own forensic labs and lack resources to properly mail confiscated wildlife specimens abroad for analysis.[152] Inadequately shipped specimens may risk the evidence's admissibility. For example, the "chain of custody" must be verifiable in order for evidence to be admitted by a U.S. court.[153] Running a wildlife forensics laboratory is also expensive. The Ashland facility operates on a $4.5 million budget each year.[154]

Possible Solutions: Construction of more dedicated wildlife forensic labs in different countries would add needed capacity while hedging against the risks of funding cuts in places like the United States. New labs may also promote the values underlying CITES. They could not only provide "a scientific center for performing forensic analysis, but also act as a catalyst to a country's entire wildlife enforcement efforts."[155] Still, not all countries encounter enough wildlife crime to justify their own lab. Regional labs that accept specimens from neighboring countries may be a solution.[156]

Another approach may be to have certain labs specialize in certain species. This would allow reference samples to be aggregated in one place. As a result, forensic scientists may specialize in certain species. Under this model, however, adequate shipping of sensitive samples remains a concern.[157]

Yet, building capacity without also achieving and ensuring quality control standards solves little. It may also exacerbate the consistency problems described earlier.[158] Significant financial investment would be required in order to create new labs and ensure that they meet the requirements of evidence security and processing. Groups like World Wildlife Fund offer financial support to police and customs officers to carry out forensic analysis in wildlife crime scene investigations. But a single nonprofit stakeholder cannot solve a global problem alone.[159] CITES Parties ought to contribute to a joint fund to build capacity at all levels of wildlife crime and enforcement. Fines collected from individual countries upon prosecuting CITES violations could also be donated to a capacity-building assistance fund.

C. Data Availability and Standardization

Problem Description: Wildlife forensic science is heavily dependent "on the existence and accessibility of reference materials against which to compare analytical results and identify evidence."[160] This material is needed at all stages of CITES enforcement—from the time a customs official decides to confiscate a specimen, to when forensic scientists attempt to identify a species. The UNODC noted that while "novel technologies and applications" are essential to forensic science, these solutions mean little without wide availability of, and access to, reference material.[161]

For example, a scientist analyzing a suspect piece of highly processed wood cannot rely solely on its appearance or DNA for identification.[162] Recently, FWS forensic scientists developed a solution to this problem using direct analysis in a real-time mass spectrometer.[163] The spectrometer, by blasting a stream of 800-degree helium onto the wood, produces a chemical "signature" unique to each species of tree.[164] A scientist can then compare this data to a library of more than 25,000 spectrometer signatures to get a positive identification.[165] Without the context the database provides, though, the spectrometer information is useless.

DNA sample databases and specimen libraries are largely absent in a number of forensic facilities around the world.[166] Labs also lack samples of bones, feathers, wood, and other visual cues needed for morphology identification, often a crucial first step in an investigation.[167] Sometimes, the delay in obtaining these from another lab, museum, or collection can take years.[168] This kind of delay prevents CITES enforcement officials from deciding whether or not to move a case forward, and it permits any wrongdoers to continue their crimes and go undeterred. It is also costly and difficult to build an adequate sample library from scratch.[169]

150. World Wildlife Crime Report, *supra* note 16, at 96.
151. *See* Fair Trade USA, Annual Report 13 (2013), http://fairtradeusa.org/sites/default/files/2013-FairTradeUSA-Annual_Report.pdf.
152. World Wildlife Crime Report, *supra* note 16, at 96.
153. UNODC Capacity Report, *supra* note 7, at 4.
154. FWS, Budget Justifications and Performance Information: Fiscal Year 2016, *available at* https://www.fws.gov/budget/2015/FY2016_FWS_Greenbook.pdf.
155. World Wildlife Crime Report, *supra* note 16, at 96.
156. *Id.*
157. *Id.*
158. *See supra* Part III.A.
159. Trace Network, *supra* note 23 (describing the Forensic Analysis Fund).
160. UNODC Capacity Report, *supra* note 7, at 12.
161. *Id.* at 26.
162. Video: Critter CSI: Solving the World's Crimes Against Nature (EarthFix Media 2015) [hereinafter Critter CSI], https://www.youtube.com/watch?v=0UgeIN6rmlU.
163. *Id.*
164. Carpenter, *supra* note 27.
165. Critter CSI, *supra* note 162.
166. UNODC Capacity Report, *supra* note 7, at 26-27.
167. Irwin, *supra* note 69.
168. *Id.*
169. *Id.*

Labs are not the only actors in the CITES enforcement chain hindered by a lack of data. Customs officials may not have a system to record incidents of wildlife trafficking or to look up whether a specimen is worth reporting in the first place.[170]

Meanwhile, databases require data standardization. This is currently lacking.[171] Under CITES, even data on wildlife seizures are not standardized. The United Nations noted that timber seizures may be reported in terms of log or container counts, weight, or volume.[172] They may also measure different types of products, such as logs or processed wood.[173] To try and gauge the number of global seizures, United Nations researchers had to consult academic and trade literature in order to create conversion formulas.[174]

The lack of data standards causes a number of enforcement problems. First, variations in the data make it harder to create a database, since information needs to be corrected by computer code or by hand. Second, different data formats make sharing information difficult, thereby hindering investigations. Last, beyond individual investigations, lack of standardized data prevents aggregation and study, thereby preventing CITES Parties from understanding enforcement impacts.

Possible Solutions: At the most recent CITES conference, the Parties adopted a resolution to study how to facilitate sampling for forensic purposes.[175] This could be accomplished in a number of ways.

First, the absence of reference samples is not always due to a lack of captured species. Many museums house collections of natural history specimens that could be used for CITES purposes. The Smithsonian Institution's Feather Identification Lab, for one, houses 85% of the world's 10,000 identified bird species, with DNA pulled for 3,500 of those.[176] The lab does not receive cases from law enforcement; rather, it focuses exclusively on bird run-ins with airplanes, wind turbines, and other sources of "strikes."[177] Its collection could be shared with wildlife forensic crime researchers working on CITES investigations.[178]

Second, reference samples need not be physical.[179] While it would require more front-end work, creation of an international sample database would ensure that laboratories around the world can access the information they need in a timely way in order to proceed with investigations.[180] Such a database could allow scientists to conduct DNA mapping and spectrometer comparisons in their own labs, even if those labs have a primarily human-forensic focus. The database could also contain morphological data, such as bone charts and feather photographs.

Third, Parties could coordinate with civil society experts and stakeholders. IvoryID was a massive undertaking, requiring the input and funding of an array of government agencies, nongovernmental organizations (NGOs), and research institutions.[181] With elephants a charismatic emblem of CITES enforcement shortfalls, it is easy to understand why that species received such attention. Creating a database for trees or reptiles, though, would be less glamorous. It would require public education, cooperation, and political will to gain similar financial and logistical support. Developing a dedicated group of stakeholders could help push other database projects forward.

Data-sharing may also help detect CITES violations at points of exit and entry. At the heart of CITES is a permit system. Permit data, if aggregated online and available for customs checkers to verify, could help stem the tide of false paperwork and fraudulent permits.

For any of these solutions, data standardization is a crucial step. The ICCWC recommended that CITES Parties standardize their data collection and storage formats in order to facilitate timely and universal access.[182] This is no simple task. Even in computer programming, developers struggle with hundreds of variations for recording date and time.[183] One project to develop a data standard for building and construction permits took several years.[184] In order to align wildlife forensics data, a dedicated, expert group would need to coordinate efforts with adequate financial support. CITES Parties may want to take a cue from the IvoryID project and first pass a resolution speaking to this intention, and then invite civil society members to participate in developing the standards.

This effort would also require buy-in from different labs around the world to ensure that standards are actually used. This ought to occur in conjunction with any lab accreditation and technician certification efforts.

D. Traceability

Problem Description: CITES enforcement is plagued by two challenges: (1) fraudulent products and (2) smuggling.[185] While both challenges threaten species viability, only the first can be addressed by increasing the amount,

170. Zagaris, *supra* note 103.
171. Indicator Framework, *supra* note 57, at 10.
172. World Wildlife Crime Report, *supra* note 16, at 29.
173. *Id.*
174. *Id.*
175. *Amendment to Resolution Conf. 11.3 (Rev.COP16) and Draft Decisions on Compliance and Enforcement*, CITES, COP17 Com. II. 25 (2016), https://cites.org/sites/default/files/eng/cop/17/Com_II/E-CoP17-Com-II-25.pdf.
176. Berger, *supra* note 9.
177. *Id.* The lab handles 8,000 "strike" cases per year.
178. Irwin, *supra* note 69. A similar, marine species-specific lab exists at the Northwest Fisheries Science Center in Seattle. *See* Northwest Fisheries Science Center, *Contact*, https://www.nwfsc.noaa.gov/contact/index.cfm (last visited May 12, 2017).
179. UNODC Capacity Report, *supra* note 7, at 12.
180. Irwin, *supra* note 69.
181. Jungcurt, *supra* note 124. The Nature Conservancy, World Wildlife Fund, University of Regensburg, and the German Federal Agency for the Conservation of Nature, among others, developed the forensic methods and database. *Id.*
182. Indicator Framework, *supra* note 57, at 10.
183. HackCraft, *Date & Time Formats on the Web*, https://www.hackcraft.net/web/datetime/ (last visited May 12, 2017).
184. BLDS Data Specification, *Homepage*, http://permitdata.org/ (last visited May 12, 2017).
185. *See supra* note 18.

type, and quality of checks along a product's route.[186] This is where principles of traceability come into play.

Detecting fraudulent products is particularly difficult with heavily processed products indistinguishable on their face, such as fish,[187] meat, wood, fabrics, and oils.[188] For example, the most common methods for tracking wood products under CITES, paint daubs and labels,[189] are highly susceptible to fraud and manipulation.

The problem of "masking" is well known in the ivory trade. In 2008, CITES regulations shifted from imposing a total ban on ivory products, to allowing ivory from certain countries to be traded.[190] This provided cover to smugglers.[191] One study estimated that 90% of the ivory now sold in China comes from newly and illegally killed elephants.[192]

Possible Solutions: CITES Parties should look to other supply-chain traceability regimes for forensic technology solutions they are using to ensure product integrity. While certification schemes that rely on such methods are not identical to CITES trade management, they share a common concern of verifying that products, plants, and animals are what they purport to be.

Whether for fair trade products or natural resource certification, all traceability schemes seek to "identify and trace an item's history, distribution, location, and application."[193] Doing so helps ensure the accuracy of an item's quality, safety, and history.[194] In order to achieve this, a system must record an item's movements from its origins to its packager, exporter, shipper, importer, and distributor.[195]

Molecular markers, developed using forensic science, are now used to track product origins.[196] The Marine Stewardship Council (MSC), the preeminent fisheries certification body, is improving its supply-chain traceability using these markers.[197] In 2009, the MSC began using "DNA barcodes" to verify fish species.[198] The technology, developed in 2003, uses a short gene sequence from a standardized position in the genome.[199] In 2011, the Food and Drug Administration (FDA) approved its use to help prevent the import of mislabeled seafood.[200] Researchers are already investigating the use of barcoding to detect trade in endangered species.[201]

DNA barcoding requires adherence to strict processes and data standards.[202] In one study, scientists concluded that wildlife DNA registers may be used to distinguish between legal and illegal takes, but only if methodological problems such as "laboratory errors and inter-laboratory data standardization" are addressed.[203] New traceability tools should be integrated into lab accreditation, certification, and other training protocols.

A reference library is also required. FDA's seafood DNA barcoding program required years of resource-intensive work to establish its Regulatory Fish Encyclopedia, a reference source with extensive species-specific identifying information.[204]

This technology would also need to be developed for CITES-specific uses. CITES Parties could develop partnerships with NGOs and academic institutions, such as the Lawrence Livermore National Lab. Researchers there developed a type of barcoding using nonviable DNA that can be sprayed directly onto food and other products.[205] While the technology is now being licensed and sold by a private company to food growers, similar advancements in the open-source and do-it-yourself biology realm may be worth exploring.[206]

Precisely because it is difficult to ensure that processed plants and animals were legally harvested and are what they purport to be, the case for forensic techniques—espe-

186. Andrea Migone et al., *From Paper Trails to DNA Barcodes: Enhancing Traceability in Forest and Fishery Certification*, 52 Nat. Resources J. 421, 427 (2012).
187. *See* Julia Whitty, *Sustainably Caught? Chilean Sea Bass? Maybe Not*, Mother Jones, Aug. 23, 2011, http://www.motherjones.com/blue-marble/2011/08/sustainably-caught-chilean-sea-bass-maybe-not.
188. Migone et al., *supra* note 186, at 425. For example, the Marine Stewardship Council discovered that 8-15% of certified "sustainably caught" Chilean sea bass either were not that fish at all, or had been landed outside of certified areas. *See* Whitty, *supra* note 187.
189. Migone et al., *supra* note 186, at 439.
190. McLendon, *supra* note 105.
191. *Id.*
192. *Id.*
193. Guide to Traceability, *supra* note 39, at 6.
194. *Id.*
195. *Id.*
196. Migone et al., *supra* note 186, at 433.
197. *Id.* at 428, 435. Traceability systems historically used among certification groups involve paper or electronic forms that checkers use to record information about a product's origin and stops along the supply chain. *Id.* at 426. Many rely on physical barcodes or radio frequency identifier devices affixed to products. *Id.* Yet, with these methods, the "integrity of the traceability trail" faces numerous obstacles. *Id.* at 426. An individual recording information on paper may write information down incorrectly, or otherwise the paper information may be entered erroneously into a tracking database. *Id.* Counterfeit goods may receive barcodes indicating that they are something they are not. *Id.* Data in electronic form may also be manipulated, allowing for illegal products to be substituted. *Id.* at 427. In addition, inspections and monitoring are costly, leaving many product certifiers to request producers and importers to engage in self-regulation. *Id.* at 427.
198. *Id.* at 425; *see also* Lucy Anderson, Marine Stewardship Council, From Ocean to Plate: How DNA Testing Helps to Ensure Traceable, Sustainable Seafood (2016), *available at* https://www.msc.org/documents/chain-of-custody-documents/from-ocean-to-plate/.
199. Consortium for the Barcode of Life, *Workshops on DNA Barcoding for Regulating Fish Species and Surveying Marine Biodiversity*, http://www.imb.dvo.ru/misc/barcoding/files/CBOL&Fish-BOL_Projects/FISH-BOLandMarineTaipeiProspectus.pdf.
200. FDA, *Single Laboratory Validated Method for DNA-Barcoding for the Species Identification of Fish*, http://www.fda.gov/Food/ScienceResearch/LaboratoryMethods/ucm237391.htm (last updated June 17, 2015).
201. *See*, *e.g.*, Bhawna Dubey et al., *DNA Mini-Barcoding: An Approach for Forensic Identification of Some Endangered Indian Snake Species*, 5 Forensic Sci. Int'l: Genetics 181 (2011); Per J. Palsbøll et al., *DNA Registers of Legally Obtained Wildlife and Derived Products as Means to Identify Illegal Takes*, 20 Conservation Biology 1284 (2006) (testing the effectiveness of a fully operational DNA register of minke whales, and concluding that wildlife DNA registers can work to combat exploitation of endangered species).
202. Migone et al., *supra* note 186, at 426.
203. Palsbøll et al., *supra* note 201.
204. FDA, *supra* note 200.
205. *Livermore Researchers Develop Spray-on, DNA "Barcode" to Instantly Trace Tainted Food*, S.F. Chron., Jan. 7, 2015, http://sanfrancisco.cbslocal.com/2015/01/07/livermore-researchers-develop-spray-on-barcode-to-instantly-trace-tainted-food-salmonella-listeria/.
206. *See*, *e.g.*, DIY Bio, *An Institution for the Do-It-Yourself Biologist*, https://diybio.org/ (last visited May 12, 2017).

cially beginning as early as possible in the supply chain—is strong. DNA barcodes that cannot be manipulated can "unequivocally establish a product's identity and origin."[207] With the rise of synthetic alternatives to endangered wildlife products, the need for embedded markings may grow.[208] This technology, along with radio-frequency identification, DNA fingerprinting, and others, may improve traceability and reduce costs over traditional monitoring and enforcement efforts.[209] A remaining issue, however, is how DNA barcoding could assure that a certain fish or tree was harvested within allowable locations—a major CITES concern.

IV. Conclusion

CITES is a powerful tool for limiting overexploitation of wildlife due to trade. Yet, while the Convention regulates millions of legal imports and exports each year, species numbers continue to decline. CITES is not fully realizing its potential.

Wildlife forensic science is "not only an essential part of law enforcement, but at the heart of wildlife protection."[210] Strengthening the Convention's use of forensic science tools can help bolster enforcement by detecting and punishing illegal trade. Forensic science may also play a key deterrent role if enough supply-chain checks and detections are in place.

In order to bridge the gaps between forensic science's potential and CITES' current use, a number of steps must be taken in unison. The Convention needs to recognize a set of quality control protocols as to what it expects global labs to follow. These protocols may derive from existing efforts to develop standards. The Parties should also consider creating a fund to support lab accreditation, individual certification, and capacity-building.

If all of the labs follow quality protocols but record data in vastly different ways, CITES will continue to fall short. Both data standardization and sharing is required. Further, CITES should encourage natural history collectors around the world, such as museums, to share their DNA and morphology samples. Doing so would help expedite CITES violation discovery and enforcement actions.

Last, CITES should look at new technological tools developed by NGOs aimed at improving supply-chain traceability. CITES is, at its heart, a permit and supply-chain regime. Though a high volume of wildlife products move under its regulation, better checks along the way are needed. This can be done using forensic science tools, such as DNA barcodes, developed by groups like the MSC.

The framework of CITES is solid, but more concentrated efforts are needed to improve its effectiveness and counter its twin challenges of fraud and trafficking. Resolutions recognizing the role of forensic science at COP17 show promising signs, as does the creation of the interagency group ICCWC. This momentum should continue. Just as Sherlock Holmes identified the rise of science tools to apply to crime investigations, CITES needs to stay ahead of the curve with wildlife forensic science.

207. Migone et al., *supra* note 186, at 435.
208. *Fear That Fake Rhino Horn Will Look So Real, It Will Hamper Efforts to Stop Illegal Killings*, Dispatch Live, Sept. 27, 2016, http://www.dispatchlive.co.za/news/2016/09/27/fear-fake-rhino-horn-will-look-real-will-hamper-efforts-stop-illegal-killings/.
209. Migone et al., *supra* note 186, at 441.
210. World Wildlife Crime Report, *supra* note 16.