Institution: King's College London		
Unit of Assessment: 5		
Title of case study: New Fingerprinting Technology to Combat the Illegal Wildlife Trade		
Period when the underpinning research was undertaken: 2016-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
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Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

To combat an estimated $23 billion a year illegal wildlife trade, King's developed a new process for recovering human fingerprint evidence on poached ivory. Until then, fingerprints were not used routinely as a source of evidence on ivory or other poached animal items due to their high instability. Toolkits developed by researchers at King's and the Metropolitan Police Service were funded by the International Fund for Animal Welfare and provided to law enforcement agencies in >40 countries where they are now in use by rangers, border officials and police at the front line. King's then contributed to Government-sponsored technology intervention strategies, Parliamentary debates leading to new legislation – the UK Ivory Act – and provided support leading to poacher arrests using fingerprint evidence for the first time. This technology enabled the City of London Police with Interpol to establish the first global fingerprint database for wildlife crime.

2. Underpinning research (indicative maximum 500 words)

King's expertise developing new approaches that enhance collection of forensic evidence. King's forensics are recognised specialists in (i) finding tailor-made ways of extracting forensic evidence when hard to do so with standard techniques (e.g. unusual scenarios) **[1]**, and (ii) developing cutting edge techniques **[2]** that add dimensions to the forensic evidence obtainable from older techniques or technologies **[3]**. Often this work creates a so-called '4th layer' of evidence; in the case of fingerprints: first is verification as a fingermark; second, identifying the distinctive features of the fingermark pattern; third, characterising the fine scale variation within this pattern; and fourth would involve adding a layer of chemical **[2,3]** or genetic information from minute amounts of biological material ('next generation fingerprinting'), to give information such as age or sex **[4]**. This expertise has established King's researchers as the go-to team for challenging (criminal) forensic investigations, regularly approached by organisations including the Metropolitan Police Service (MPS) **[1,5]** and City of London Police (CoLP), who are the primary agencies in London responsible for tackling international illegal wildlife trade. These relationships led to the formation of a partnership to improve the use of forensic evidence for criminal cases relating to illegal wildlife trade.

Enforcing the protection of endangered animal species is a critical issue. Critically endangered species, such as elephants, rhino and pangolin have been devastated by poaching in recent years. This has been fuelled by a rise in popular demand for illicit horn and ivory-based items, mainly in Asia, and owing to perceived medicinal benefits. The Great Elephant Census in 2016 (Elephants Without Borders and others) reported that Savannah elephants declined by 30 % between 2007 and 2014. An estimated 84% of the surveyed population were sighted in legally protected areas. Safeguarding animals in these reserves through identifying and prosecuting poachers remains a critical issue for survival and to support conservation efforts. Furthermore, the illegal wildlife trade (IWT) funds large-scale international organised crime syndicates.

Established forensic methods were not used effectively in tackling IWT. In many conservation areas, forensic capability to identify poachers was either non-existent or under-developed. Basic technology was often lacking, including the use of fingerprint evidence. Furthermore, traditional black powders used in fingerprinting only retrieve usable ridge detail from ivory for a maximum of two days. As a result, fingerprint recovery was largely dismissed during forensic IWT investigations. Since fingerprint evidence accompanied by DNA profiling is the largest contribution forensic laboratories can make in such cases, this is a significant sacrifice in capability.

King's developed an effective method to detect fingerprints on ivory for up to 28 days. King's were the first group to successfully use these new powders to obtain fingerprint evidence on poached ivory items – the first ever demonstration of retrieving stable, forensic-quality fingerprints from elephant ivory beyond 2 weeks. King's, in partnership with the Metropolitan and City of London Police, using Met seed funding of £3,000, investigated the ability of recently commercialised, reduced particle size powders to improve the recovery of fingerprint details from ivory to a forensically useable level **[5]**. King's researchers:

a) compared physicochemical properties, sensitivity and practicality of two reduced-size powders (≤40 μm average particle diameter, magnetic vs non-magnetic cores) relative to conventional, coarse grained powder (~100 μm average particle diameter). They found that the new powders increased fingermark quality due to their smaller size and because improved amphiphilicity led to stronger interactions with water, amino acids and lipids in smaller sweat deposits. With this approach, 95 % of recovered fingerprints were suitable for manual comparison with reference prints by expert fingerprint examiners, and 15/20 marks were successfully identified automatically using IDENT1, from the UK fingerprint database containing more than 7 million sets of ten-prints;

b) assessed the enhanced fingerprint detail quality with respect to location on a tusk and age of deposits, and found that sampling a tusk's mid-section was most effective given its smoother nature and that smaller, lighter particles did not dislodge as easily; this was especially important for sampling older marks containing less sweat material up to 28 days after deposition; and

c) demonstrated improved performance over alternative chemical treatment methods, such as cyanoacrylate fuming, with greater enhancement ability, contrast, practicality and non-destructive action on ivory material with reduced-scale powders. They also showed that the results were not significantly improved by sequential treatment with these alternative methods and the powder alone was sufficient, especially for older marks on ivory.

King's developed a fingerprint toolkit for use in the field. King's subsequently created a user protocol, toolkit and instructional video for police, customs officials and rangers to use at crime scenes in the field. The kit offered a simple, 'low-tech' solution for law enforcement bodies with limited forensic science capability to use in the field and included Fingerprint powder, magnetic applicators, magnifying glass, secure locks, lifting tapes, gloves, photograph scales and mounts and fingerprint tape cardbacks. A kit lasts 2-3 years (>10,000 sets of fingerprinting tests), the powder is reusable and consumable elements are inexpensive to replace, making this fit-for-purpose technology in countries without established forensic infrastructure.

Developing 'touch DNA' methodology and analysis to extract genetic information from fingermarks. The early results of the Kenyan pilot of the toolkit and its review by the international body for wildlife crime (ICCFWC; see section 4), raised the possibility of combining DNA evidence with fingermark evidence, by extracting and analysing DNA material from fingerprints. However, analysing very small amounts of DNA is challenging. King's identified knowledge gaps about forensically relevant touch depositions **[6]**, and has worked to increase the sensitivity of detection methods, pursuing 'touch DNA' techniques and analysis, and developed cutting edge ways of analysing very small amounts of DNA **[7,8]**.

3. References to the research

1. Porpiglia N, Bleay S, Fitzgerald L, Barron L. (2012). *An assessment of the effectiveness of 5-methylthioninhydrin within dual action reagents for latent fingerprint development on paper substrates.* Science & Justice 52 (1), 42-48. DOI: 10.1016/j.scijus.2011.04.006

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Analyst 137 (7), 1576-1583. DOI: 10.1039/c2an16126e
3. Love C, Gilchrist E, Smith N, Barron L. (2013). *Detection of anionic energetic material residues in enhanced fingermarks on porous and non-porous surfaces using ion chromatography.* Forensic Science International 231 (1-3), 150-156. DOI: 10.1016/j.forsciint.2013.04.017
4. Vidaki A, Ballard D, Aliferi A, Miller TH, Barron LP, Court DS. (2017). *DNA methylation-based forensic age prediction using artificial neural networks and next generation sequencing.* Forensic Science International: Genetics 28, 225-236. DOI: 10.1016/j.fsigen.2017.02.009
5. Weston-Ford, K.A., Moseley, M.L., Hall, L.J., Marsh, N.P., Morgan, R.M., Barron, L.P. (2016). *The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials.* Sci. Jus. **56** (1), 1-8. DOI: 10.1016/j.scijus.2015.10.003.
6. Burrill, J., Daniel, B. & Frascione, N. (2018). *A Review of Trace "Touch DNA" Deposits: Variability Factors and an Exploration of Cellular Composition.* Forensic Sci Int: Genetics. DOI: 10.1016/j.fsigen.2018.11.019.
7. Burrill, J., Kombara, A., Daniel, B. & Frascione, N., (2021). Exploration of cell-free DNA (cfDNA) recovery for touch deposits. Forensic Sci Int: Genetics. 51, 102431. 10.1016/j.fsigen.2020.102431
8. Burrill, J., Daniel, B. & Frascione, N. (2020). Illuminating touch deposits through cellular characterization of hand rinses and body fluids with nucleic acid fluorescence. Forensic Science International: Genetics. 46, 102269. DOI: 10.1016/j.fsigen.2020.102269.

4. Details of the impact

King's equips international law enforcement agencies with new fingerprint technology. Established in 1975, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a multi-lateral treaty to protect endangered plants and animals involving 182 states and the EU. Following publication of the original research, in 2016 King's was invited to speak at an event on combatting wildlife crime alongside then Director General of CITES, John Scanlon, and the FBI, hosted by the US Embassy in London. This directly led to investment of ~£10,000 by the International Fund for Animal Welfare (IFAW) to provide 200 toolkits, free of charge, to law enforcement bodies internationally (from >40 countries) **[A, B, C]**.

Fingerprinting toolkits are now in use by rangers, police officers and customs officials in Africa, Europe and Asia. Following field trials and as a result of the collaboration with IFAW, the kits are being trialled in over 40 countries globally **[A, B]**. In total, ~200 kits are being used across Africa, Europe and Asia: By 2017, there were 40 kits in use across 9 countries; by 2018, over 100 kits in 23 countries; and at the 2018 IWT conference, hosted by the Foreign and Commonwealth Office (FCO), a further 100 toolkits were distributed (sponsored by IFAW) **[C]**. Kits are now in use at Interpol, CITES, UNODC, the World Bank and enforcement agencies including UK, France, Germany, Kenya, USA, Malawi, Zambia and UAE; for example, being used by Sussex Police responsible for Gatwick airport, and the French environmental crime department OCLAESP **[A-F]**. King's have also worked with the MPS and CoLP to provide training on the kits and fingerprint technology. For example, in 2018 King's provided training on forensic technologies to police IWT at the British Consulate Hong Kong (funded by the Consulate General) by invitation of the Hong Kong Customs and Excise Department, the Agriculture, Fisheries and Conservation Department (AFCD) of the Government of Hong Kong, and Hong Kong University (HKU) researchers – who work closely with the customs and border force to identify poached goods and to recover evidence **[D]**. King's left two kits with the HKU team to deploy in their IWT investigations and building on existing links between King's and Hong Kong forensics teams, King's advise annually on new technologies to combat IWT **[D]**.

The International Consortium for Combatting Wildlife Crime (ICCWC) incorporated King's technology into their toolkit. King's were contacted by the ICCW, the premier body governing strategy for this issue globally with five key members: The World Bank, CITES, Interpol, The World Customs Organisation and the UN Office on Drugs and Crime (UNODC). They independently reviewed the toolkits with five international forensic experts and made a series of recommendations in their resulting report **[E]**. Subsequently, with additional seed funding from the Metropolitan Police Service (GBP 3,000), King's made improvements to the technology such as successfully integrating DNA profiling techniques, developing a method to secure a DNA profile without any interference from the applied powder and progressing the development of a fingerprint

database to add even more evidential value. The technology is now included in the ICCWC Toolkit to combat IWT globally **[A]**.

The Kenyan Wildlife Service used King's toolkits to obtain evidence leading to 15 arrests of suspected poachers. Following a successful trial of the first toolkit in 2016, the Kenyan Wildlife Service, who are responsible for protection of ~10 % of the current African elephant population (~35,000), were given 14 additional kits by IFAW, which are now in routine use **[A, C]**. Crucially, rapid introduction and training support from King's led to 15 arrests in four separate poaching cases shortly afterwards **[F]**. Five of the arrests were of police officers, showing that this technology also helps tackle corruption. Prior to this, arrests were extremely difficult to secure, demonstrating the immediate power of this technology to help formal identification and prosecution of criminal activity **[A, F]**.

King's technology enabled the creation of an international fingerprint database to police IWT. Led by the City of London Police (CoLP) Director of Forensic Services (now Fellow of King's College London) Tracy Alexander, in October 2018 the first internationally accessible fingerprint database for poachers was launched in collaboration with Interpol: *"One of the immediate critical elements that was missing from implementation of these new kits was the availability of a searchable database. CoLP developed and hosted the first ever internationally searchable database for fingerprint evidence for wildlife crime…This has opened up a new stream of activity for us on a global level. The Mineral Flora and Fauna Unit, a Section within the Zimbabwe Republic Police, is one of the organisations that has benefited from crime scene training and this database. King's and CoLP have trained their officers to develop fingermarks from surfaces including rhino horn and ivory as well as introducing them to a range of forensic disciplines to aid their investigations. The improvement in process has led to arrests and convictions."* **[B]**.

Providing expert testimony to support the development of UK legislation tackling IWT. Dr Barron was invited to discuss and demonstrate the toolkit to politicians of both Houses of Parliament during two IFAW events at the Houses of Commons and Lords: in September 2017, to support the lobby for MPs on the Ivory Bill, and in May 2018 to launch the IFAW Wildlife Cybercrime report **[A, G]**. As a result, King's research on IWT was raised by the Foreign Secretary and in subsequent UK Parliament debates during development of the new legislation. In February 2018, prior to the official introduction of the Bill, the then Foreign Secretary, Boris Johnson visited the Metropolitan Police Service' Wildlife Crime Unit and spoke about King's research in the fight against IWT, calling for more international efforts to tackle IWT. He described learning about King's new technique for taking fingerprints from ivory and how it increases the chance of building a legal case against perpetrators **[G1]**. The most important reference to King's work occurred during consideration of the Ivory Bill – introduced to Parliament in May 2018, aiming to ban the trade, import and export of ivory in the UK. King's fingerprinting technology was specifically mentioned in the first reading debate (June 2018) as a critical technology that could help tackle all areas of crime, not just IWT, in countries with limited forensic capacity **[G2]**. The Ivory Act 2018 passed in both Houses of Parliament in December 2018 and is now an Act of Law **[G3]**.

Providing expert advice to the Royal Society (RS) and Foreign and Commonwealth Office (FCO) on emerging IWT technology. Across 2017/18, Dr Barron was invited by the RS Vice-President to contribute to a science policy paper on emerging technologies relating to IWT. He joined other recognised experts, practitioners and RS Fellows in September 2017 to discuss key strategic technologies worth pursuing to combat IWT, ultimately shortlisting five key interventions. In 2018 the subsequent joint report by the RS and the FCO used King's research as a specific example of new scientific technology achieving critical impact in the field **[H]**. The report recommended five critical interventions to combat IWT, of which the fingerprinting toolkit is mentioned as an exemplar. The toolkit is highlighted in the Ministerial preface by Dr Thérese Coffey MP (then Parliamentary Under Secretary of State for the Environment) and Rt Hon Mark Field MP (then Minister of State for Asia and the Pacific) **[H]**; both have shown support, visiting Africa to see the kit in use by rangers and customs officials **[B, C]**. The FCO endorsed the toolkit and distributed to attendees of the 2018 IWT conference.

Increasing the ability of the City of London Police to gather forensic evidence of IWT. The Director of Forensic Services explained the importance of this work for the CoLP in fighting IWT, including extending the technology beyond ivory: *"The global financial cost of illegal wildlife*

trade is estimated to be in the region of £17 billion dollars per annum and has strong links to drug trafficking and gun crime.… This led to the development of a pioneering toolkit to identify usable fingermarks on ivory to try to interrupt the trade at source and develop crime scene skills of wildlife officials. The City of London Police (CoLP) have since worked together with King's to advance this research for frontline policing efforts for pangolin scales and other poached wildlife items…. (The research) has led to a significant shift in our ability to gather powerful forensic evidence… and to support development and application of a searchable international database. Prior to this, no reliable methods existed for recovery of fingermark evidence from poached items in the UK and it was almost impossible to search fingerprint matches on an international scale. Similarly, only poachers caught in the act were prosecuted. As a result, there were very few, if any, cases that involved collection of fingermark evidence.... In many developing countries, laboratories do not exist or have limited capability and resources to deploy complex instrumentation into the field for wildlife forensics. Fingermark development does not require significant technical expertise or resources and… allows integration with our database. This project… is of immense importance to us at CoLP and… we have been able to integrate it into our practice and into training programmes delivered internationally. Without a doubt, King's were fundamental to the advancements we have made in the battle against illegal wildlife trade." **[B]**.

Enhancing the reach, scope and leverage of IFAW's work to stop international wildlife crime. As the UK IFAW Director explains, King's work has helped gain traction for coordinated global action against IWT: *"IFAW is now developing scene of crime management training and kits, which will incorporate the ivory fingerprinting technology, and has expanded our wildlife crime portfolio, providing technologies and resources in to countries that will enable rangers, police and Custom officers to help stop the illegal trade in wildlife. None of this would have been possible without the research. (…) Together with King's, we have also enabled the introduction of a new forensic science strand to INTERPOL and the International Consortium to Combat Wildlife Crime (ICCWC) activity in this area. This is something we have strived to improve for many years and especially in range countries having often poor forensic capability…. What has impressed many people around the world is that this theoretical research has a clear practical application that has proven itself in the field. It is a simple, fit for purpose technology that has significantly enhanced our ability to achieve our vision of wildlife protection and conservation."* **[A,** see also **I]**.

5. Sources to corroborate the impact

[A] Testimonial, UK Director, IFAW. **[PDF]**

[B] Testimonial, Director of Forensic Service, City of London Police **[PDF]**

[C] Evidence of kits distribution & use: **C1** IFAW deployment of toolkits by 2017. **C2** IFAW fingerprinting update 2017. **C3** 2018 IWT conference: FCO announcement - official handover of ivory fingerprinting kits; images with law enforcement agencies; London Conference on the IWT (October 2018): Declaration (64 national signatories). **C4** UK FCO (Zimbabwe) blog on kits in use. **C5** Images of the toolkit, elephant tusk with fingermarks.

[D] Evidence of training Chinese authorities on forensic approaches to IWT.
'Tackling the Illegal Wildlife Trade' presentation, invited by the UK FCO British Consulate General, Hong Kong: https://www.youtube.com/watch?v=IDtTv3aA9tQ&feature=youtu.be

[E] Evidence of ICCWC reviewing use of the fingerprinting toolkit to tackle IWT: report with recommendations on toolkit and IFAW and King's responses **[PDF]**

[F] Evidence of KWS using kits, leading to prosecutions in Kenya **[PDF]**

[G] Contributions of expertise at Parliament leading to the Ivory Act 2018. **G1** The Foreign Secretary's speech on visiting the Metropolitan Police Wildlife Crime Unit. **G2** House of Commons, Public Bill Committee, First reading debate of the Ivory Bill: (Tuesday 12 June 2018 Hansard, columns 11, 15). **G3** The Ivory Act 2018. **[PDF]**

[H] Evidence of expert advice to the RS & FCO **H1** The Royal Society & FCO Technology Update "Science: tackling the illegal wildlife trade" (2018) (ISBN: 978-1-78252-360-4). **H2** Therese Coffey MP visiting the Kenyan Wildlife Service to observe new fingerprint technology. **[PDF]**
[I] Examples of events and media raising public awareness of IWT and forensic science.