



DEAD ZONE: This elephant was killed inside Chad's Zakouma National Park last October when poachers trained automatic weapons on a grazing herd. It is one of the estimated 38,000 annual victims of the illegal ivory trade.

In 1983 while exploring a small forest called Malundwe on the edge of the Selous Game Reserve in Tanzania, one of us (Wasser) came across two elephant skulls lying side by side. One, from a female, was big, and the other was small—it had molars just a quarter the size of the female's and they had not yet been used enough to show any signs of wear. The poachers had first shot the young elephant, a ranger explained, so that they could draw its grieving mother close enough to kill her for her enormous tusks. This exploitation of familial ties in the sophisticated social system of elephants has been repeated thousands of times in Africa.

The Selous Game Reserve is the largest protected area in Africa but was nonetheless among the most heavily poached during the well-publicized slaughters that occurred between 1979 and 1989. At least 700,000 elephants were killed during this period—70,000 in the Selous alone. Then, in 1989, Tanzania's new director of wildlife launched a major antipoaching initiative called Operation Uhai. The combined effort of wildlife rangers, police officers and the

military rapidly brought an end to most poaching in the country.

Tanzania then joined six other countries in successfully petitioning for the agreement administered by the United Nations known as CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) to list the African elephant as an Appendix I species. This ruling effectively banned all international trade in elephants and their products. Publicity surrounding the issue turned public sentiment so far against the ivory trade that it nearly eliminated the demand for ivory worldwide; most poaching stopped abruptly in response. Western nations helped to maintain the calm by pouring large sums of aid into antipoaching efforts throughout Africa. Collectively, this was probably the most effective act of international wildlife legislation in history, and public pressure was instrumental to its success.

But the lull was short-lived. Some African countries opposed a continent-wide ban from the outset and never stopped advocating for its



The Ivory Trail

The illegal slaughter of African elephants for ivory is now worse than it was at its peak in the 1980s. New forensic tools based on DNA analysis can help stop the cartels behind this bloody trade

By Samuel K. Wasser, Bill Clark and Cathy Laurie

reversal. Aid from Western countries dried up, leaving poor African nations with plenty of antipoaching equipment but no money for upkeep. Ivory also became an important status symbol among the new middle class in the industrial countries of the Far East such as China and Japan. Demand from these and other wealthy nations, including the U.S., drove the wholesale price for high-quality ivory from \$200 per kilogram in 2004 to \$850 per kilogram by 2007. The price doubled again by 2009. Chinese authorities estimated the retail value of 790 kilograms of ivory seized in southern China in March 2008 at \$6,500 per kilogram.

Under pressure from African countries that wanted to sell their ivory as well as the Eastern nations that wanted to import it, CITES eventually decided to permit two one-time legal sales of ivory stocks. In each case, the ivory had to be obtained by natural deaths or legitimate culling of problem animals only. Individual countries had to apply to participate in the sale and demonstrate progress in curbing their country's illegal ivory trade. A monitoring program was

also established to determine whether the legal sales would promote increased poaching (although its data were never deemed sufficient to answer this question).

By 2006 poaching had become arguably worse than it was before the ban. That year between 25,000 and 29,000 kilograms of ivory were seized en route from Africa. Major crime syndicates had become involved in the trade, eager to capitalize on this growing demand, particularly because prosecution risk remained low and the liberalization of global trade made it easy to move large volumes of contraband. Based on the 2006 seizures, we estimate that more than 8 percent of the African elephant population is being wiped out annually [see box on page 72]. This mortality rate exceeds the elephants' 6 percent annual reproductive rate under optimal conditions and even exceeds the 7.4 percent annual poaching mortality rate that instigated the ban.

To stop this slaughter, law-enforcement agents need to target their operations at the locations where the elephants are being poached.

KEY CONCEPTS

- After the near elimination of elephant poaching following the 1989 ban on ivory, demand has returned. Elephant populations are now being decimated like never before.
- Researchers can now accurately map elephant populations over the entire African continent using the DNA in their scat.
- Scientists use this map and DNA extracted from ivory to trace illegal shipments back to their source. The first results from three major seizures show that sophisticated criminal networks are targeting specific groups for intense exploitation. —*The Editors*

estimated wholesale value of \$4.6 million and a retail “street value” upward of \$21 million.

SATURDAY, JULY 8, 2006, SAI YING PUN, HONG KONG ISLAND—Five days after the Taiwanese seizure, a local resident reports a terrible burning stench coming from a neighbor’s apartment. Police and fire units respond quickly. No one replies to their knocks on the door, so the units force their way in. They discover seven people cutting and packing what turns out to be 2.6 metric tons of elephant ivory. Hong Kong authorities seize 390 tusks plus another 121 cut pieces. Some clues indicate an East African origin.

MONDAY, AUGUST 28, 2006, OSAKA HARBOR, JAPAN—Japanese customs agents discover 608 pieces of raw ivory, which, when carefully matched, produce 260 whole tusks. At 2.8 metric tons, this is the largest ivory seizure ever reported in Japan. Many of the tusks are numbered with Swahili writing [see illustration on page 76], suggesting an East African shipping source. Also in the incoming consignment are 17,928 carved ivory cylinders, obviously intended for the signature seal, or *hanko*, market. The Japanese and Chinese engrave their individual seal at one end of these signature seals—also called chops—and use them to stamp their personal checks, legal documents and letters. (Though currently among the most common uses of ivory, this is a relatively recent development; *hankos* were historically made of materials such as jade.) Yet the Japanese do not report the seizure at the 2006 CITES standing committee meeting that was to decide whether to allow Japan to be a purchaser of a one-time ivory sale from southern Africa. On October 7, 2006, the newspaper *Asahi Shimbun* breaks the story, and Japanese authorities acknowledge the shipment soon thereafter.

When we learned of the seizures, we requested samples of the ivory so that we could subject them to DNA analysis at the University of Wash-

ington Center for Conservation Biology. The results would be shared among the donor countries, the International Criminal Police Organization (Interpol) and the Lusaka Agreement Task Force, an agency of African countries cooperating to fight wildlife crime. Hong Kong and Taiwan voluntarily agreed to provide ivory samples. Despite numerous requests, Japanese authorities have not yet supplied any samples.

DNA Map

We extract DNA from ivory using a pulverization technique borrowed from dental forensics. We place a piece of ivory about the size of a peanut inside a polycarbonate tube along with a magnet, then seal the tube with stainless steel plugs. Next, we drop the sample into liquid nitrogen at -240 degrees Celsius inside a device called a freezer mill. There a magnetic field oscillates rapidly back and forth, smashing the ivory against the plugs and breaking it into a fine powder. Throughout this process the low temperature maintains the integrity of the DNA. Using now standard techniques, we isolate the DNA from the powder and obtain a profile of variation in DNA segments called microsatellites to get a DNA fingerprint [see box on opposite page]. Microsatellites consist of anywhere from

The pattern of geographic origin can provide clues about how poachers operate.

WHITE MARKET: Open ivory markets such as the one below in Kinshasa, Democratic Republic of Congo, have expanded to support the rising ivory trade. But the real surge in ivory demand is driven by the industrial nations of the Far East, where individuals use signature seals called *hankos* (below left) to stamp documents.

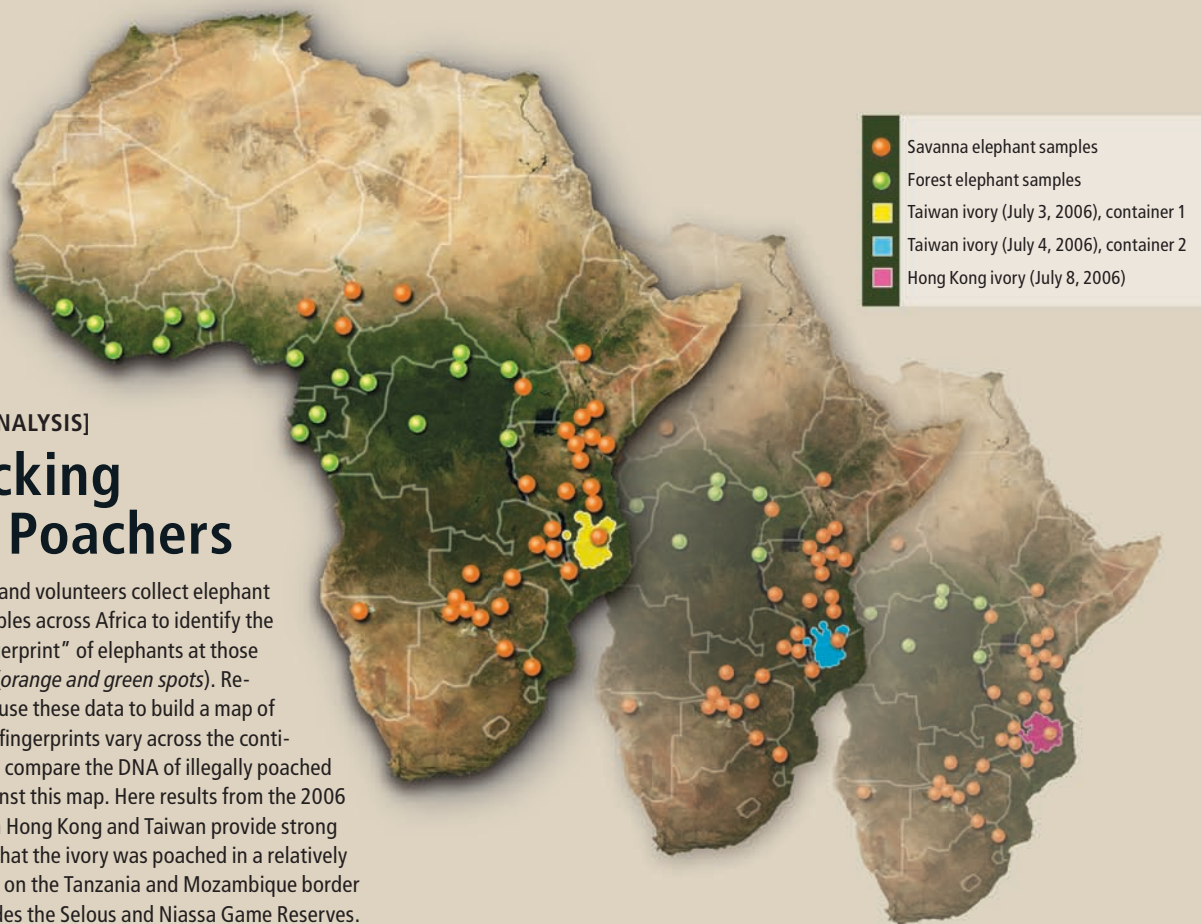
MICHAEL FREEMAN/Aurora Photos (seal/5); PATRICK ROBERT Corbis (market)



[DATA ANALYSIS]

Tracking the Poachers

Scientists and volunteers collect elephant dung samples across Africa to identify the DNA “fingerprint” of elephants at those locations (*orange and green spots*). Researchers use these data to build a map of how DNA fingerprints vary across the continent, then compare the DNA of illegally poached tusks against this map. Here results from the 2006 seizures in Hong Kong and Taiwan provide strong evidence that the ivory was poached in a relatively small area on the Tanzania and Mozambique border that includes the Selous and Niassa Game Reserves.



HOW MANY ELEPHANTS ARE BEING KILLED?

Rampant poaching in the period between 1979 and 1989 reduced the elephant population across Africa from 1.3 million to fewer than 600,000 individuals, a loss of 7.4 percent a year. Fast-forward to 2006, and the illegal ivory trade had once again escalated to levels few people anticipated. Between August 2005 and August 2006, authorities seized more than 25 metric tons of ivory. Customs commonly assumes that a 10 percent seizure rate for “general goods” contraband is successful, and so the authors estimate that more than 250 metric tons of ivory were smuggled that year. Using the commonly accepted estimate of 6.6 kilograms of ivory per elephant, they conclude that 38,000 elephants—8 percent of the entire African elephant population—are being killed annually.

two to four nucleotides repeated from 10 to 100 times. Unlike functional genes, microsatellite DNA does not code for proteins. Thus, the number of repeats in the microsatellite can vary without affecting the health of the organism or its ability to reproduce, and changes in the repeat number tend to arise frequently and persist. Over time, then, microsatellites in one population come to differ among geographically separated populations.

With a DNA fingerprint of microsatellite repeats from a tusk in hand, we now compare this to a map of DNA fingerprints from elephants across Africa. A decade ago we set out to create a reference map across the whole of the continent that would plot the variation in microsatellite DNA. This project turned out to be a much bigger challenge than we anticipated.

Africa is a huge continent and the precision of our ivory assignments is directly tied to the comprehensiveness of our DNA map. To facilitate the collection of reference DNA, we extracted it from elephant populations in the least invasive way possible—through their feces. Each gram of elephant feces contains DNA from millions of sloughed off intestinal mucosal cells. Collecting enough feces to create a reference map across Africa required the help of many sci-

entists and wildlife wardens, and we are indebted to them for their efforts. But no matter how many elephant dung samples we are able to collect, we will never have enough to completely cover the entire continent.

To knit together swatches of patchy data, we use a statistical technique we devised called the smoothed continuous assignment technique (SCAT). Software employing the SCAT method extrapolates data gathered at discrete locations to compose a continuous geographic distribution of DNA fingerprints—the microsatellite DNA lengths at each of the 16 loci—across the entire elephant range. This method relies on the fact that populations close to one another tend to be genetically more similar than populations that are more distant. We validated the SCAT procedure by using it to determine the origin of dung samples taken from known locations.

Anatomy of a Shipment

We first applied our DNA assignment method to a case that exemplifies the magnitude and complexity of the modern ivory trade. In February 2002 authorities in Malawi, working with Zambian authorities and the Lusaka Agreement Task Force, raided a family ivory-carving factory that was ostensibly using ivory legally

acquired from the Malawi government. The factory, however, had far more ivory than it had legal documentation for, and very few of the samples had the requisite government stamp. The haul included many residual scraps of ivory with bored holes from which short cylinders had been cut. These cylinders were thought to be *hanko* signature seals destined for Japan. (Japanese traditionally prefer cylindrical seals, whereas Chinese prefer square ones.)

Detailed records recovered in the Malawi raid described 19 separate shipments made by these traffickers during the preceding nine years. All shipments identified the same shipper, the same shipping codes (either soapstone or sawn timber) and the same origin. Nearly all had the same destination. One of these consignments included a 6.5-metric-ton shipment of ivory (recorded as soapstone), which was at a hidden location, waiting to be delivered.

That June authorities suddenly learned that the missing ivory had been trucked to Beira, Mozambique, and loaded on a ship to Durban, South Africa, where it was transferred onto another ship destined for Singapore. Local authorities were notified of the shipment just four hours before its arrival and confiscated the container. The shipment included 532 tusks, with an atypically large average weight of 12 kilograms per tusk, and 42,000 *hanko* seals. The signature seals were cylindrical, and their diameters matched the bored holes in the ivory scraps seized in Malawi. Several tusks in the seizure were marked with “Yokohama,” a port city near Tokyo.

The shipping documents recovered in the Malawi raid did not list the weights of the 18 other illegal ivory shipments. If we assume that each shipment was similar in size to the Singapore seizure, however, they would collectively represent close to 110 metric tons of ivory, or approximately 17,000 poached elephants.

The huge quantity of seized contraband was a striking indicator of the growth of the illicit ivory trade. It also revealed how much of it is controlled by major crime syndicates. Moving this much ivory requires expertise in commodity trade, international finance and other commercial disciplines. The business requires significant infrastructure in the Far East capable of receiving and processing tons of ivory, factories that can produce tens of thousands of *hankos* a year, and a marketing, distribution and retail network to sell them. The millions of U.S. dollars generated in sales must be illegally laun-

dered through legitimate business channels and then moved around the world to pay for new shipments. Further, high-level bribery is evident. There have been reports of poachers using large volumes of wildlife products as barter currency for the weapons and ammunition needed to keep corrupt officials in power.

And while profit is high, the risk to traffickers is low. Few major wildlife traffickers ever get prosecuted, because wildlife crime is generally considered a low priority among law-enforcement agencies when compared with terrorism, drug trafficking, murder and financial crime. Virtually no one involved in the Singapore seizure was ever prosecuted, including the customs agents who signed their names to the manifest declaring the ivory to be soapstone. In several other countries, penalties for getting caught are cheaper than paying sales tax.

Hard and Fast

Although investigators strongly suspected that the ivory confiscated in Singapore was processed at the facility in Malawi, DNA analysis was necessary to determine whether the samples came

The huge quantity of contraband revealed how much of the illicit ivory trade is controlled by major crime syndicates.

Elephants Are Not Alone

Illegal wildlife trafficking of many species and their products is burgeoning throughout the world, far exceeding current monitoring and enforcement capacity. Credible studies from multiple sources indicate that illegal trade in wildlife can be valued at tens of billions of U.S. dollars annually. The liberalization of global trade has helped spread the market for illegal wildlife products, as has technology: recent research indicates significant amounts of dubious elephant ivory are being offered for sale on the Internet. The considerable legal trade in rare wildlife—more than 100 million individuals of rare species are bought and sold every year under CITES—also provides an ideal conduit for illegal trade. And as with ivory, it is becoming clear that criminal syndicates are behind much of it. In just the past few years, authorities have made a series of disconcertingly large busts, confiscating 55,000 reptile skins in India, 19,000 bigeye thresher shark fins in Ecuador, 23 metric tons of pangolins in Asia, 3,000 Tibetan (*shahtoosh*) shawls from at least 12,000 antelopes in India, and 2,000 Indian star tortoises (*below*), also in India.

—S.K.W.



If the trade is not brought under control soon, most of Africa will lose the majority of its free-ranging elephants.

from the same source. The results provided strong evidence that all the ivory had a common origin. The tusks and *hanko* seals from the Singapore seizure as well as the ivory scraps seized in the Malawi factory raid all originated from a population of savanna elephants centered on Zambia. Linking the *hankos* to the same population as the tusks in the Singapore seizure explained the mysterious absence of small to medium tusks in that seizure. Smaller tusks were likely carved into *hankos* at the ivory-carving facility in Malawi. This strategy almost certainly served to increase the value of the consignment to a Japanese market, as the Japanese historically prefer large tusks. It also indicated that animals of all ages fell victim to these poachers. It takes a very large number of young elephants to provide enough ivory to manufacture 42,000 signature stamps.

This 2002 seizure occurred in the same year

that Zambia petitioned CITES to allow its stockpiled ivory to be included in a one-time sale to the Far East. Yet CITES ultimately rejected this proposal, in some degree because of suspicions that some of the ivory recovered in Singapore came from Zambia. Our results help to validate that decision.

Analysis of the ivory in the Singapore seizure showed for the first time how poachers were targeting specific populations for intense exploitation. Populations were hit hard and fast, presumably to satisfy specific purchase orders from buyers. This finding contradicted the more common belief that traffickers were employing a decentralized plan of assembling large consignments by opportunistically procuring ivory stockpiles as they became available across Africa. It also meant that using these techniques to focus law enforcement on identified hotspots should prove to be a viable antipoaching strategy.

Are There Too Many Elephants?

Following the ivory ban, some people became caught up in the myth that Africa now has too many elephants. Media reports focused on a small number of southern African countries that demanded to legally cull elephants because of high population densities in protected areas such as wildlife refuges; escalating human-elephant conflict seemed to back those claims. Yet the problem is far more complicated than it appears.

Most of the protected areas with high elephant densities in southern Africa are fenced, which severely restricts the elephants' natural movements. Far more countries throughout Africa, including several countries in southern Africa, are experiencing substantial poaching-related declines among elephants. The raging debates over culling frequently overshadow these points, yet they offer a simpler solution: tearing down those fences and creating megaparks that transcend international boundaries. Many of the now fenced populations border countries with low human and elephant population densities that offer considerable land for elephant movement. The megaparks would dilute any high-density pockets of elephant activity and thus blunt the impact on the rest of the food chain.

There is also disagreement as to the causes of human-elephant conflict. Such conflict most often happens when elephants wander outside their protected areas and into nearby farms. Loss of habitat is usually cited as the prime cause, but the effect of poaching on elephant social structure also plays a large role. Older adult females have consistently been among the first to be poached—aside from big adult males, they have the largest tusks, and female social groups are a lot easier for poachers to find than solitary adult males. A 1989 study found that 80 percent of the skulls recovered from poached elephants were females, with a mean age of 32 years. These old females, called matriarchs, play a pivotal role in elephant society, directing group movements and maintaining the group's competitive standing and social cohesion. With their leaders lost and "protected areas" no longer offering safe haven because of poaching, elephants wander. Indeed, massive elephant exoduses have been well documented during the slaughters that occurred in the civil wars of Mozambique, Angola and elsewhere. These leaderless elephants move out of their protected areas, encounter rich crops, mistake the poor people defending them for poachers, and fight for their lives.

—S.K.W.

Business as Usual

Our more recent studies of the summer 2006 seizures in Taiwan and Hong Kong show just how much the current destruction mirrors the slaughter of the 1980s. The 2006 operations also involved a high level of organization and much political intrigue. Our DNA analysis revealed that the tusks came from an area centered on the Selous ecosystem in Tanzania, spilling over into the Niassa Game Reserve in northern Mozambique [see box on page 72]. It appears that Tanzania has once again become a hotbed of illegal poaching activity. This is the country that is home to Serengeti National Park; Gombe Stream, where Jane Goodall carried out her famed chimpanzee research; Mount Kilimanjaro; the Eastern Arc Mountains, a world-renowned hotspot on the edge of the Selous that has more endemic



JOHN HRUSA/Corbis



UNSOLVED BUST: Just weeks after the Hong Kong and Taiwan seizures, authorities in Osaka, Japan, confiscated 608 pieces of raw ivory totaling 2.8 metric tons (*left*). The authorities have not yet provided samples for DNA analysis, so it is impossible to say with certainty where the ivory originated; however, circumstantial evidence such as Swahili lettering on many of the tusks (*below*) implies Tanzania as an origin (Swahili is primarily spoken in Tanzania and Kenya).



species per square kilometer than any other place in the world; and of course the Selous Game Reserve itself. Tanzania petitioned CITES to sell its stockpiled ivory that same year but withdrew its application in response to international pressures.

One open question is whether the ivory impounded in Osaka also originated in Tanzania. While our lab was analyzing the seizures from Taiwan and Hong Kong, Japanese authorities concluded their work on the bust—the biggest ivory-smuggling attempt in Japanese history. In 2007 a Japanese court convicted a man of attempting to smuggle the 2.8 metric tons of ivory. He received a suspended sentence and a fine equivalent to less than 1 percent of the customs estimate of the ivory's retail street value. Japanese authorities then incinerated the ivory, thereby making it unavailable for DNA analysis. They did retain a collection of about 100 small pieces, each weighing an average of 0.3 gram. Yet these pieces have not been made available and, even if they were, we are uncertain that they could yield enough DNA for analyses. Earlier that year Japan received final CITES approval to purchase ivory from a legal sale that would occur in 2008.

These sales are problematic, no matter how carefully they are monitored. The existence of legal domestic ivory markets, particularly in the Far East, influences public perceptions and legitimizes the fashion for ivory. Legal markets likely absorb a large portion of the smuggled ivory and provide an easy way to launder the rest. How else can hundreds of thousands of

ivory carvings be entered into retail consumer trade, if not via conventional retail merchants?

Industrial consumer countries with markets for contraband ivory have not been providing credible support for wildlife agencies in African elephant habitat countries, despite the fact that it is their citizens who provide the financial incentive for nearly all the poaching. Developing countries in Africa are left extremely vulnerable to the power and money that wildlife crime syndicates wield, power that is fueled by the wealth of industrial economies. Although DNA analysis can help concentrate law-enforcement efforts, more help is needed to stop the slaughter. As we write, the killing continues: on March 9, 2009, Vietnam authorities confiscated a shipment of 6.2 metric tons of ivory, which was reportedly smuggled from Tanzania. This constitutes the second-largest ivory seizure since the ban.

Public sentiment contributed significantly to stopping the illegal ivory trade in 1989, and improved public awareness of the elephant's peril could achieve this again. By our estimates, more than 38,000 African elephants were killed for ivory in 2006 alone. All evidence suggests that the poaching rate has still not slowed, and indeed there are reports of intensified poaching from some countries. If the illegal ivory trade is not brought under control soon, most of Africa will lose the majority of its free-ranging elephants, and Africa will never be the same. That is too great a price to pay for a commodity whose principal use is vanity. ■

➔ MORE TO EXPLORE

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