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ELEPHANT IVORY: AN OVERVIEW OF CHANGES TO ITS STRINGENT REGULATION AND CONSIDERATIONS FOR ITS IDENTIFICATION

STEPHANIE E. HORNBECK

Elephant ivory has been considered a prized luxury material across world cultures from ancient times to the present day. Elephant ivory is the most highly valued of all ivories and describes the material comprising the tusks of Asian male and African male and female elephants, as well as that of their relative, the mammoth. Today the collection of ivory art and artifacts is inextricably linked to the plight of the African elephant and its status as a seriously threatened species, as demand for elephant ivory has risen sharply in the last decade. In 2014, international and US national laws were again strengthened to combat the rise in trafficking of elephant ivory. The 2016 revision of the African elephant rule under section 4(d) of the Endangered Species Act aims to achieve a near-total ban in commerce of raw and worked ivory and affects transit of legally documented worked ivory art and artifacts as well. As conservators may be involved in the identification and sampling of ivory materials, it is important to be aware of the methods to identify ivory and new regulations that apply to it.

KEYWORDS: Elephant ivory, CITES, Endangered Species Act, Ivory identification, Ivory regulation, Poaching, Trafficking, US Fish and Wildlife Service

1. INTRODUCTION

The collection of ivory art and artifacts is inextricably linked to the plight of the African elephant and its status as a seriously threatened species, as demand for elephant ivory has risen sharply in the past decade. According to the Wildlife Conservation Society, in 2012, an estimated 35,000 African elephants—the equivalent of 96 per day—were killed for their ivory tusks (Wildlife Conservation Society 2016). Consequently, in 2014, international and US national laws were strengthened to combat the rise in trafficking of ivory, including trade of ivory artworks and artifacts. The Illegal Wildlife Trade Conference convened in London on February 13, 2014, to discuss key actions to eliminate the illegal wildlife trade. In 2014, the United States, the second largest market in the world (after China), strengthened sanctions on importing African ivory. In February 2014, the US Fish and Wildlife Service (FWS) announced that it would temporarily ban the trade in African elephant ivory to the United States by prohibiting all commercial imports and exports of raw and worked ivory, regardless of age and including sales by auction houses and other art dealers; this administrative action was revised to allow for narrow exemptions under the new rule change to revise the African elephant rule under section 4(d) of the Endangered Species Act (ESA), which became law in July 2016 (US Fish and Wildlife Service, 2016b).

As conservators may increasingly be involved in the examination, and possibly sampling, of ivory artifacts, the objective of this article is to present a background context for, and discussion of, relevant aspects of new regulations and to provide a review of the criteria to identify elephant ivory. Responsible stewardship of worked ivory art objects and artifacts involves respect for the new regulations aimed at elephant conservation.

Fig. 1. Nimrud (Kalhu) Iraq, *Cow and calf furniture element*, 850–700 BC, ivory and metal. Collections of Bolton Library and Museum Service, BOLMG 1964.2.3.A. Copyright Bolton Council (Courtesy of Stephanie Hornbeck)

2. THE ART OF ELEPHANT IVORY

Elephant ivory has been considered a cherished luxury material across cultures from ancient times to the present day. Highly prized for its creamy luster and workability, ivory has been used for sculpture in Africa, Asia, and Europe for millennia and later in the Americas as international trade routes expanded. The inherent value of ivory, its attractive visual qualities, and its ability to be carved and worked, combined with royal patronage for the creations of highly skilled carvers, have yielded master artworks in many world cultures. Some of the most admired ancient works were derived from royal commissions for the Assyrian Empire (fig. 1). Historical accounts describe a colossal 10 m tall chryselephantine—ivory and gold—statue of Athena by master sculptor Phidias that once stood inside the Parthenon. Medieval Europe saw the rise of demand for ivory ecclesiastical objects, and Paris in particular became an important ivory carving center. Ivory carving centers existed throughout Asia and Southeast Asia.

This article will primarily present examples of African ivory artworks (figs. 2–4), as my ivory research has focused on the study of these works. Ivory, from the elephants that produce it to the intricately carved artifact, is a material closely associated with Africa.

Ivory is a relatively soft material, which enables it be worked with non-metal tools, and its surface can be highly polished, yielding the characteristic glossy, creamy, and semi-translucent surface for which

Fig. 2. Yoruba peoples, Owo region, Nigeria, *Bracelet*, 16th century, ivory, 14.5 × 10.5 × 10.5 cm. National Museum of African Art, 2005-6-8. Gift of Walt Disney World Co., a subsidiary of the Walt Disney Company (Courtesy of Franko Khoury)

it is much admired. As it ages, it often develops a yellow-golden patina. Ivory can be bleached to whiten it, and it can be stained with oils, dyes, and colorants to achieve a range of warm brown colors (figs. 3, 4). Paint and gilding were sometimes applied to ivory. Thus, the possible presence of a surface alteration or coating is important to consider when identifying ivory.

3. THE ELEPHANT IVORY MARKET

It is noteworthy that although ivory has historically been prized by cultures within Africa, perhaps most famously by the ancient Egyptians and the Kingdom of Benin (fig. 5), internal consumption was limited—often restricted to royalty—and did not put elephant populations at risk. However, the establishment of international trade with Africa had dire consequences for elephant populations throughout the continent. Demand for ivory, variously under the ancient Roman Empire, with India and the Far East, and eventually with Europe and North America, historically impacted elephant populations in various regions of the continent. Demand in the 20th and 21st centuries has seen the greatest decimation of African elephants, continent-wide. Trade networks brought the raw material to North America, where it has been widely used in the past two centuries to manufacture combs, handles, billiard balls, and piano keys, along with art objects. In the 19th century, the United States

Fig. 3. Note the pale cream coloration. Kongo peoples, Congo, *Tusk* (detail), ca. 1860, ivory, 72.4 × 14.6 × 6 cm. National Museum of African Art, 96-28-1. Bequest of Mrs. Robert Woods Bliss (Courtesy of Franko Khoury)

was the world's greatest consumer of ivory. For a period of about 150 years (1830s–1980s), the largest ivory processing plant in the United States operated in the village of Ivoryton in Essex, Connecticut, which at one time processed up to 90% of all elephant ivory imported into the United States (Malcarne and Milkofsky n.d.).

The populations of both African and Asian elephants have declined dramatically since the mid-20th century. According to the FWS (the federal agency that regulates and enforces compliance with national and international importation laws that apply to fauna and flora), although habitation destruction and fragmentation increasingly threaten elephant populations, the greatest threat to their survival is poaching—illegal killing—to supply the highly lucrative ivory market. Because both female and male African elephants have tusks, they are particularly susceptible to poaching. In 1900, the African elephant population was 10 million (Christy and Hartley 2013). In recent decades, their population has declined from 1.2 million in 1980 to 420,000 in 2012 (Wildlife Conservation Society 2016). The situation is more dire for Asian elephants, whose population is less than 45,000 (Nelleman et al. 2013).

Fig. 4. Note the deep red-brown coloration. Kongo peoples, Democratic Republic of the Congo, *Figure with Child (mvuala)*, late 19th to early 20th century, ivory, mirror, resin, pigment, 13.3 × 5.1 × 5.7 cm. National Museum of African Art, 86-2-1. Museum purchase (Courtesy of Franko Khoury)

At present, China is the largest consumer of elephant ivory, considered emblematic of status and wealth (fig. 6) and also used in alternative medicine. According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Elephant Trade Information System (ETIS), most of this ivory is obtained illegally in Africa to be carved and sold in Asia (ibid.). Thailand is another large consumer, and Vietnam, Malaysia, and the Philippines are also major trade routes; most seized ivory is found in ocean vessel shipping containers from East African ports, primarily in Tanzania and Kenya (ibid.).

The fates of elephants are affected for good or ill by human activity. In regions with effective wildlife conservation methods in place, as in southern Africa, their populations demonstrate increases, whereas those in regions of civil strife show a population decline. In April 2015, the African Elephant

Fig. 5. Carved elephant tusks adorn a royal altar. Eliot Elisofon, *Benin Palace Ancestral Altar for Oba Ovonramwen*, 1970, photograph. Eliot Elisofon Photographic Archives, National Museum of African Art, EEPA EECL 07590 (Courtesy of Eliot Elisofon)

Summit convened in Kasane, Botswana, and announced that the African elephant could be hunted to extinction within 10 to 20 years (Beaudufe 2015). It is worth remembering that an ancient elephant sub-species native to Turkey, Iraq, and Syria, the Syrian elephant (*Elephas maximus asurus*)—the largest of the Asian elephant sub-species at 3.5 m tall—was hunted to extinction in the 8th century BC in direct relation to ivory demand for luxury objects.

Some southern African regions—mainly the countries affected by embargoes—are experiencing an increase in elephant populations. Yet poaching continues to be an enormous issue for regions that cannot adequately oversee vast elephant ranges. Attempts to staunch poaching and illicit trade, while addressing increasing stockpiles of ivory from elephants that have died of natural causes, are dilemmas that have international implications.

4. REGULATIONS: TOWARD ELEPHANT CONSERVATION

The intersection of the ivory trade with elephant conservation efforts has resulted in an international consensus for ivory regulation. Several laws instituted over the past 40 years strictly regulate its legal trade. These have broad application and affect museums and individual collectors, among other entities. Loopholes in laws and regulations, exemptions for trophy hunting, and differing interstate laws for African and Asian elephant ivory have contributed to a crisis situation in the making since

Fig. 6. An ivory shop in Hong Kong; note the placard displaying a rendering of a mammoth, implying the goods are mammoth ivory. 2016, National Geographic (Courtesy of Paul Hilton EPA)

before 1976 (when the first convention on the trade of animal parts was instituted) and are exacerbated by spiking demand since 2007. The stated reasons provided by the FWS for the increased restrictions on worked African elephant ivory include that the United States remains a significant ivory market and that the legal ivory trade can provide a cover for illegal trafficking of ivory (US Fish and Wildlife Service 2016c).

A series of international and national laws and regulations protect the trade of ivory. CITES, formed in 1975, became the only global treaty to ensure that international trade in plants and animals does not threaten their survival in the wild. It provides a framework for cooperation and collaboration among nations to prevent decline in wild populations of animals and plants. At present, 182 countries, including the United States, implement CITES. All Asian elephant populations and most African elephant populations are listed on CITES Appendix I, species that are most endangered—threatened with extinction. Although legally binding on the parties (countries that have voluntarily agreed to be bound by the Convention), CITES regulations do not take the place of national laws.

4.1 EMBARGOES

In 1989, CITES member countries agreed on a world-wide ban on the trade of ivory. This historic vote came after the African elephant was deemed "threatened" due to excessive poaching to meet market demand. Earlier that year, conservationist and Kenyan Wildlife Director Richard

Fig. 7. A pile of elephant ivory, valued at $3 million, confiscated by Kenyan game wardens and burned by authorities, July 1989, Nairobi, Kenya (Courtesy of Tom Stoddart Archive)

Leakey persuaded the Kenyan government to burn 12 tons of elephant tusks (fig. 7) rather than sell them to call international attention to the devastating effects of the ivory trade (Christy and Hartley 2013).

Additionally in 1989, the countries of Botswana, Namibia, South Africa, and Zimbabwe implemented ivory trade embargoes. At present, ivories carved before the 1989 ban are designated as "pre-Embargo" works of art. In 2007 and 2008, CITES eased the embargo by allowing these countries to sell government-owned ivory amassed before 1989 to Japan and China, respectively, stipulating that a

Fig. 8. Stockpile of confiscated elephant ivory before crush outside of Hong Kong in January 2014. Hong Kong is one of the largest commercial centers of illegal ivory. (Courtesy National Geographic Voices)

percentage of the proceeds must be directed toward elephant conservation. The sales to Japan and China were restricted to use within domestic markets; ivory from these sales could not be traded internationally. Yet these well-intentioned sales had the opposite desired economic effect of driving down the demand for ivory by increasing supply, and instead, since 2007, demand soared and poaching increased again (Christy and Hartley 2013).

4.2 SANCTIONED CRUSHES OF CONFISCATED STOCKPILES

The Wildlife Conservation Society has reported recent destruction of stockpiles of confiscated illegal raw and worked ivory by governments around the world (Wildlife Conservation Society 2016). Like the 1989 bonfire in Kenya, destroying the ivory by crushing or burning ensures that it cannot re-enter the market as the valuable commodity it once was. In 2013 and 2015, the FWS pulverized holdings of confiscated illegal ivory from the United States in a concrete crusher. Since 2014, more than 20 countries and territories, including Belgium, France, Kenya, Gabon, the Philippines, and Hong Kong (fig. 8), have also crushed confiscated ivory. In 2016, Kenya once again held the world's largest ivory destruction event when it burned 105 metric tons (ibid).

However, ivory artifacts with historical value may unfortunately be mixed in with the more recent carvings in crushes. National Museum of African Art Curator Bryna Freyer explains that when historically important artifacts are crushed, not just the animal is lost but cultural heritage "dies" as well (Freyer, pers. comm.). In an important precedent, before the 2015 crush in New York's Times Square, museum experts reviewed confiscated items, and two objects considered historically important were set aside from destruction.

5. US FEDERAL LAWS

Since the 1970s, the international trade of elephant ivory has been highly regulated by several laws; these apply to the importation and travel of artifacts across international and national borders. Sometimes the laws overlap, in which case the stricter law applies:

- *The Lacey Act (1900 and later amendments)*: Prohibits trade of wildlife taken in violation of any state or foreign wildlife law or regulation; affects interstate commerce.
- *The Endangered Species Act (1973)*: Designed to prevent the extinction of native and foreign species of wild fauna and flora; lists Asian elephants as "endangered" (in danger of extinction) and African elephants as "threatened" (in danger of becoming endangered). This act prohibits elephant parts and products, including worked ivory objects, from being imported into the United States except under certain conditions. This act was strengthened in 2016 with the implementation of a final rule revising section 4(d) of the African elephant rule, which narrows the number of allowed exceptions (see section 5.1) (US Fish and Wildlife 2016b, c).
- *The African Elephant Conservation Act (1988)*: Prohibits the import of raw or worked ivory into the United States with certain exceptions. This act also established a grant program to fund elephant conservation efforts. Figure 9 depicts an elephant herd in the wild near Namanga, Kenya.

In July 2013, while visiting Tanzania, President Obama issued an executive order committing the United States to increase efforts to combat wildlife trafficking (US Fish and Wildlife Service 2016b). Executive orders engage the entire US government, including all federal agencies. This executive order led

Fig. 9. Eliot Elisofon, *Elephants in Amboseli National Park*, West of Namanga, Kenya, 1959, photograph. Eliot Elisofon Photographic Archives, National Museum of African Art, EEPA EECL 24721 (Courtesy of Eliot Elisofon)

to new federal regulations in 2014, including a series of administrative actions with different timelines, implementing a nearly complete ban on commercial import of African elephant ivory into the United States. In July 2016, the FWS enacted the proposed 2015 rule change to rule 4(d) of the ESA to increase protection of African elephants by limiting commercial activities (ibid).

Federal law cannot stop ivory from being sold within a state's borders. Consequently, since February 2014, 14 individual states in the United States—California, Connecticut, the District of Columbia, Florida, Hawaii, Illinois, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington—have introduced bills to comply with new FWS regulations to ban the commerce of African elephant ivory. New Jersey (implemented May 2014) and New York (implemented June 2014) were the first to implement state laws prohibiting elephant ivory commerce (Wildlife Conservation Society 2016).

5.1 IMPACT ON MUSEUMS AND PRIVATE COLLECTORS

Exceptions to the revised African elephant rule of the Endangered Species Act have been retained for legally documented antique (older than 100 years) worked ivory objects, which were temporarily impacted by the 2014–16 FWS restrictions, and objects that are part of a traveling exhibition (US Fish and Wildlife Service 2016b, c). Appendix I to Director's Order 210 describes acceptable documentation, requiring proof of age and designation of elephant species (US Fish and Wildlife Service 2016a). A new so-called *de minimis* exception to the rule has been added to allow for the commerce of objects with small amounts of worked African elephant ivory components (fig. 10), provided that specific criteria are met, including that ivory is not the primary material or in raw form and that ivory components total less than 200 g (US Fish and Wildlife Service 2016c).

The FWS has compiled a useful table and informative list of questions and answers about the ESA rule change to guide owners and stewards of African elephant ivory artifacts; topics include Import, Export, Sales across State Lines (Interstate Commerce), Sales within a State (Intrastate Commerce),

Fig. 10. Indian, *Writing box*, 16th century, wood inlaid with ivory, 34.3 × 53 × 13 cm. Metropolitan Museum of Art. Purchase, Pat and John Rosenwald Gift, 2004. (Courtesy of Metropolitan Museum of Art)

Non-Commercial Movement within US, and Personal Possession (US Fish and Wildlife Service 2016c). Among the questions and answers provided are two in particular that apply to museums and collectors (US Fish and Wildlife Service 2016c):

> **What requirements must be met to import African elephant ivory as part of a traveling exhibition?** Worked African elephant ivory may be imported as part of a traveling exhibition, such as a museum or art show, provided that the ivory was legally acquired prior to February 26, 1976; the person or group qualifies for a CITES traveling exhibition certificate; and the item containing elephant ivory is accompanied by a valid CITES traveling exhibition certificate or an equivalent CITES document that meets the requirements of 50 CFR 23.49. Raw African elephant ivory cannot be imported as part of a traveling exhibition. (p. 11)

> **How do I demonstrate that my item meets the criteria to qualify as an antique under the ESA?** We have provided guidance in the Appendix to Director's Order 210 on ways to demonstrate that an item qualifies as an ESA antique. We want to clarify that forensic testing is not necessarily required. Provenance and age may be determined through a detailed history of the item . . . [or] a qualified appraisal or another method, including using information in catalogs, price lists and other similar materials that document the age by establishing the origin of the item, can also be used. (p. 9)

When ivory travels into the United States from abroad, it must enter at one of 13 approved so-called antique ports. These are Anchorage, Baltimore, Boston, Chicago, Honolulu, Houston, Los Angeles, Miami, New Orleans, New York, Philadelphia, San Francisco, and San Juan, Puerto Rico.

The 2016 regulations:

- Render transit of artifacts more complicated, as different ivory products have differing legal requirements because laws differ across state, national, and international boundaries (e.g., CITES and ESA protections differ for African and Asian elephants).
- Involve stricter transit requirements designating species identification and age documentation, including those for ancient worked ivories of known provenance.
- Have complicated considerations for composite artifacts, some containing small pieces of ivory (see fig. 10) that are difficult to accurately identify or date. They have also complicated considerations for legal ivory artifacts that may have undocumentable ivory repairs.

The FWS can amend the regulations, as has happened for example for Director's Order 210, so it is important to check their website for current information.

5.1.1 Case Study: Traveling Museum Exhibition

A recent exhibition installation experience encapsulates these new issues. In October 2014, I assisted the Bolton Museum, based in Bolton, England, with the West Palm Beach, Florida, installation of an international traveling exhibition of ancient Egyptian artifacts. Among the objects were 13 ancient ivories (e.g., mirror handles, kohl containers, bracelets, cups, and plaques) composed of elephant (see fig. 1) and hippopotamus ivory.

The exhibition had been traveling since 2011 and came into Miami International Airport via Hong Kong in September 2014, where the ivories and several other organic artifacts, including human and animal mummies, which shared the same bill of lading as the ivories, were delayed release for 5 days by the Miami office of the FWS. All of the artifacts had CITES permits, although these had been renewed while the objects were in Hong Kong, perhaps signaling a red flag to the FWS agent, as Hong Kong is a major center for the ivory black market in China.

For 4 days, the ivories and animal mummies were held in their carrier airline's warehouse, to which we did not have access and to which we could not confirm if climate controlled. Miami has a tropical climate, with ambient relative humidity typically above 70%, which could yield structural damage or mold growth on organic artifacts acclimated to drier conditions. In compliance with the new

2014 regulations, the Miami FWS agent asked for species identification of the elephant ivories, which the curator could not readily provide from existing documentation about the artifacts. It is not atypical for the origin species of an ancient elephant ivory artifact to be unknown. Indeed, destructive analysis would be the only way to provide such information. These ivories had never undergone such testing. We cited the exception to the new regulations for documented worked elephant ivories that were part of a traveling exhibition to the FWS agent. Eventually, after this case was passed up to FWS headquarters in Washington, DC, the non-ivory artifacts were released. One day later, the ivories were released on the condition that species identification be provided on transit out of the United States, achieving a temporary reprieve for exhibition.

6. A REVIEW OF IVORY FEATURES AND METHODS OF IDENTIFICATION

As the new regulations are implemented, conservators may need to identify ivory or its substitutes, so a review of ivory features and methods of identification is useful. The material ivory includes the highly valued tusks and teeth of the following mammals: mastodons and mammoths (both extinct), elephants, hippopotami, walruses, warthogs, sperm and killer whales, and narwhals. Elephant ivory is the most highly valued of all ivories and describes the material comprising the tusks of Asian male elephants and African male and female elephants, as well as that from their relative, the mammoth. Although they share the taxonomic family Elephantidae, African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) are different species.

The tusks of elephants, although differing in function, are directly related anatomically and compositionally to the teeth of other mammals. Elephant tusks correspond to incisors. Tusks can grow to 3.5 m in length (some African males) and weigh up to 90 kg (165 lb.) each. Like teeth, tusks have a pulp cavity where the root and soft tissue attach it to the jaw of the animal. The pulp cavity extends for approximately two-thirds of the tusk; its presence or absence on a carved ivory artifact can indicate the part of the tusk that was used and the original length of the tusk. Also like teeth, tusks are composed of dentine and cementum; however, teeth also have a hard outer layer of enamel, which is found only at the tip of tusks. Like living bone and dental tissues, ivory tusks are composed primarily of an inorganic component, calcium hydroxyapatite (approximately 60%), and an organic component, collagen (approximately 40%).

Visual examination under low magnification (fig. 11) remains one of the most useful methods to identify ivory, particularly if diagnostic features are present. It can be difficult to discern structures on worked ivory artifacts, especially if they are deteriorated or small in section (as for inlays). It is important to compare the object in question against reference materials and good detail images of elephant ivory, ivory from other mammals, and ivory substitutes (for diagnostic images, see Penniman [1984], Krzyszkowska [1990], Espinoza and Mann [1992], Hornbeck [2010/16], US Fish and Wildlife Service [2010], and Mann and Marts [2013]).

The characteristic visual identifier of elephant ivory is the presence of a pattern of intersecting arcs sometimes called *engine turnings*, *cross-hatching*, or *Schreger lines* (named after the German anatomist Bernhard Gottlob Schreger, who first described them in 1800) visible in cross section.

This intersecting arc pattern is present only on mammoth and elephant ivory; acute arc angles on mammoth ivory (fig. 12) distinguish it from elephant ivory (figs. 13, 14), which has obtuse arc angles. No other mammal ivories have the pattern, nor do natural material substitutes. The pattern can be viewed with the naked eye or under low magnification. However, the absence of the pattern does not absolutely negate a material, as working/cutting the ivory from different angles, especially tangential, may yield sections that do not show the pattern.

Fig. 11. An inexpensive simple adaptor lens can be fitted to the camera lens of a smartphone or media device to turn it into a microscope. This adaptor can zoom in to magnify, and one can view the feature in real time, take photos, and share them. Here, Stephanie Hornbeck uses a smartphone microscope adaptor to examine Nimrud ivory objects. (Courtesy of Stephanie Hornbeck)

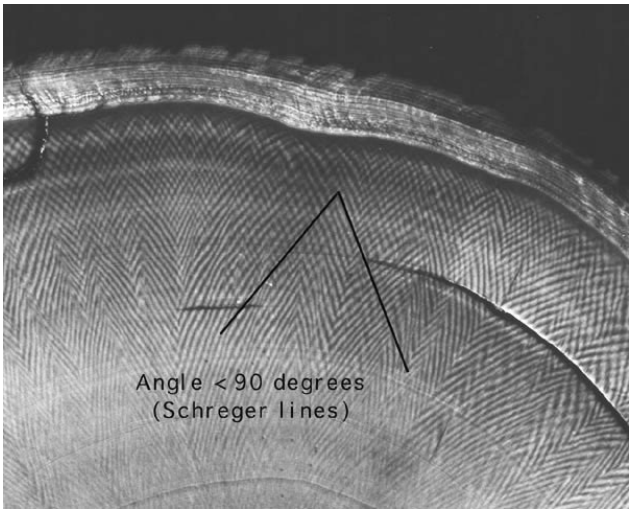

Fig. 12. Note acute angles of intersecting arcs (Schreger lines) on cross section of mammoth ivory. (Courtesy of US Fish and Wildlife Service and the World Wildlife Fund)

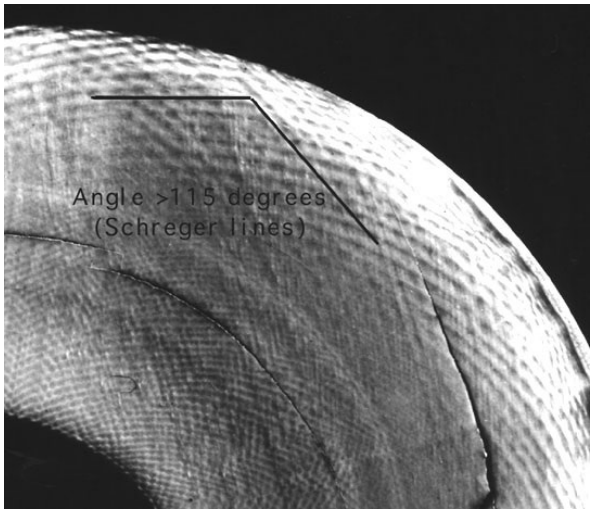

Fig. 13. Note obtuse angles of intersecting arcs (Schreger lines) on cross section of elephant ivory. (Courtesy of US Fish and Wildlife Service and the World Wildlife Fund)

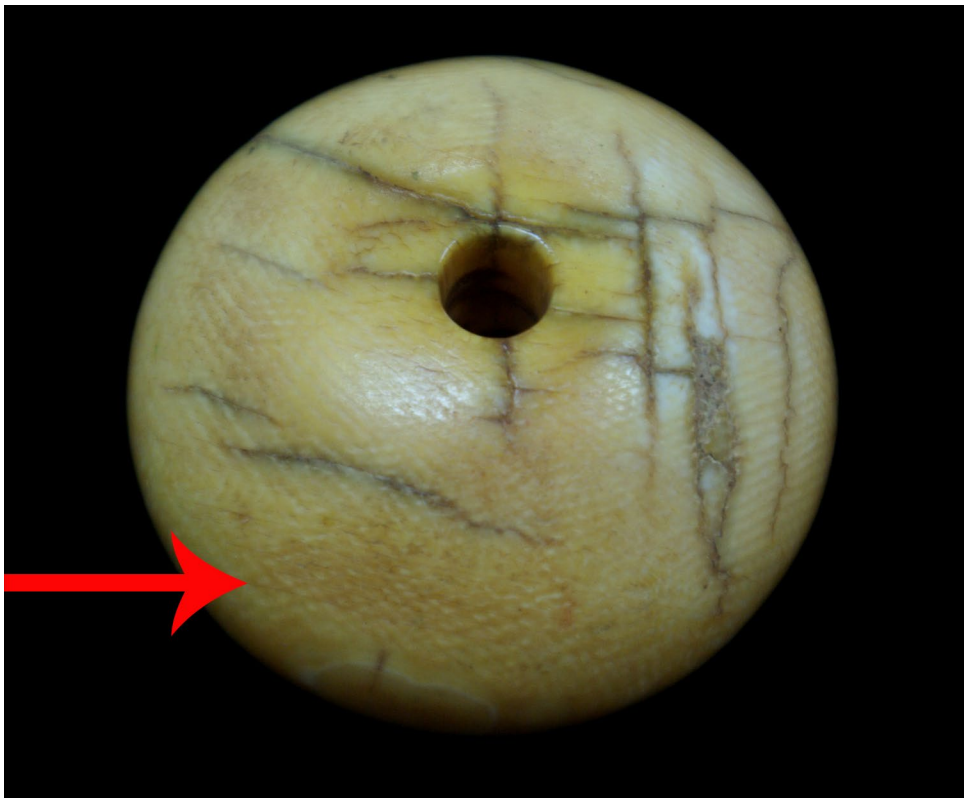

Fig. 14. Note the presence of intersecting arcs (Schreger lines) on the object. Turkana peoples, Kenya, *Labret*, mid-20th century, ivory, 5.0 × 5.5 × 3.3 cm. National Museum of African Art, 2004-9-3. Gift of Eileen Sobeck (Courtesy of Stephanie Hornbeck)

6.1 ELEPHANT IVORY SUBSTITUTES

As with other natural materials of high value, several substitute materials, including other mammal ivories and natural and synthetic materials, have been used to emulate elephant ivory. Now with the increased regulation of elephant ivory commerce, art vendors are increasingly identifying their objects as mammoth ivory or another substitute to circumvent the regulations, even if the material is actually elephant ivory. Thus, it is helpful to recognize the characteristics of these substitute materials as well.

Other animal ivories include mammoth tusk, mastodon tusk, hippopotamus teeth, sperm whale and killer whale teeth, narwhal tusk, walrus teeth and tusk, and warthog tusk.

Other natural materials include bone (historically the most often substituted material for ivory, characterized by the Haversian system of elongated holes from blood vessels), antler (outgrowths of bone), horn (keratin-based composition), shell, and vegetable ivory (also known as tagua or "ivory nuts").

Synthetic materials include various composite mixtures, such as ivory dust and casein, ivory dust and styrene resin, calcium carbonate and adhesive, casein and hardener, and plastics, typically celluloid. Celluloid is a proprietary plastic composed of cellulose nitrate and camphor developed in the 19th century. One of its primary uses was as an ivory substitute.

The provenance and age of an ivory artifact may shed light on the geographic origin of the material, which can narrow down the possibilities for identification. For example, elephants are not indigenous to North and South America, so prior to the establishment of international trade routes in the mid-16th century, elephant ivory could not have been used in these regions. If the ivory object was fabricated in the northern-most regions of Europe, Asia, and North America, it is as likely to be mammoth or walrus ivory as elephant. If the artifact was fabricated after the mid-19th century, it could be plastic.

The size of the artifact can indicate the source of its material. Elephant tusks from adults are much longer than other mammal ivories, most bones, vegetable ivory, and shells. Hence, a long, uninterrupted section may be indicative of elephant ivory. Similarly, because vegetable ivory derives from palm nuts that grow up to 5 cm in diameter, only whole artifacts that are small in size (i.e., miniatures, snuff boxes, cane heads) could be fabricated from this material. The weight of the object can also be a telling qualifier. Ivory and bone are heavier than shell, horn, composite mixtures, and plastics, which are all lightweight materials.

6.2 AGED ELEPHANT IVORY

As ivory desiccates, it loses its surface luster and becomes harder. With the passage of time, these changes can make visual identification more difficult. Indeed, ancient ivory, bone, and wood (as from archaeological contexts) can appear quite similar, sometimes requiring the use of analytical testing for identification. Thus, it is useful to know what aged ivory looks like. The deterioration of ivory is directly related to its composition and formation. Unlike the teeth of living mammals, the dentine layers of tusks are produced annually, somewhat similar to tree rings in cross section (Uno et al. 2013). Once these mammals are no longer living, the organic components of ivory deteriorate over time. Low humidity levels can result in separation or delamination of the layers of dentine (fig. 15), visible in cross section as a

Fig. 15. Directional cracking can yield delamination of ivory layers. Yoruba peoples, Nigeria, *Tusk* (detail), 19th century, ivory, 130 × 12.2 × 10.4 cm. National Museum of African Art, 79-16-47. Bequest of Samuel Rubin (Courtesy of Stephanie Hornbeck)

cone-within-a-cone pattern. Checks and cracks occur in longitudinal and radial planes in locations related to gaps in formation. Radial cracks form in the manner that wood splits along the grain. Cracks in the transverse plane follow the formation of dentine. In combination, directional cracking patterns can cause the ivory to exfoliate in curved rectangles. (For detail images of different types of deterioration, see Hornbeck [2010/16].)

6.3 TESTING/ANALYTICAL METHODS

More recent stringent regulations for elephant ivory will likely involve an increased necessity for testing to precisely identify elephant species and ivory age. Unfortunately, such precise requirements can only be served by destructive methods. It would be a very worthwhile endeavor for a conservation scientist to focus on development of a micro-analytical method that requires only a tiny sample. A review of the known methods to characterize elephant ivory is useful. The latter three methods are forensic techniques more appropriate for raw ivory than worked ivory artifacts.

Examination under longwave ultraviolet radiation can be diagnostic. Ivory fluoresces a bluish-white color, as do bone and shell. However, vegetable ivory fluoresces slightly orange and plastics absorb light, giving them a dull, matte appearance.

An older diagnostic test involves touching a small, obscure area of the object (i.e., the bottom) with a hot needle to indicate the presence of plastic or horn. Plastics will typically soften and emit a chemical odor (camphor in the case of celluloid), and horn will soften and smell like burned hair, whereas true ivory will not soften, although it may eventually char. This method may leave a permanent mark on the object and is not recommended for worked ivory artifacts.

If a more precise quantitative characterization is required, a sample may be submitted to analytical testing with Fourier transform infrared spectroscopy (FTIR). FTIR can differentiate ivory from its imitators, with the exception of bone, which is very similar in chemical composition.

DNA analysis has emerged as a precise method of identification and geographic sourcing (Wasser et al. 2004). The method utilizes a sample of ivory from which mitochondrial and microsatellite DNA can be isolated for comparison against data sets. This analytical method can differentiate between African (*Loxodonta africana*) and Asian *(Elephas maximus*) elephant species, and within a species it can distinguish forest from savannah dwellers. Furthermore, genetic variation within a geographic region indicates that ivory could be traced back to specific countries, and within those countries, even to specific forests. If enough organic material remains in aged samples, it is possible to extract DNA data from them as well. This method is promising for sourcing ivory confiscated from illegal trade, potentially enabling greater surveillance of specific geographic regions suspected of poaching.

Stable isotope analysis can trace origins and migration of wildlife source areas (Ziegler et al. 2013). Isotope markers, such as strontium-90, which substitutes for calcium in the minerals of skeletal tissue, can serve as a geochemical signature to source ancient and recent bone and ivory to a specific geologic area. Stable isotope ratios are based on stable isotope signatures in animal tissues that reflect local food sources and geology, and they can be used for tracing the origin or migration of wildlife. This principle has also been applied to determine the source of ivory; samples of at least 30 mg are needed.

Bomb curve radiocarbon analysis can accurately date ivory during and after the period of 1952–62, the "bomb curve" (Uno et al. 2013). The dramatic increase from 1952 to 1962 and subsequent decline of carbon-14 in the atmosphere relates to the testing of nuclear weapons. The technique uses accelerator mass spectrometry applied to the carbon contained in both collagen and the mineral apatite within ivory to provide an age of death of the animal from which the ivory originated. Bomb-curve radiocarbon analysis can provide a date within 2 years for samples dating after 1952. Such analysis is a potentially useful wildlife forensic method for recent ivories, although the sample size of at least 25 to 50 mg of collagen or 150 mg of apatite is not insignificant for many small ivory artifacts.

7. AIC POSITION PAPER ON AFRICAN ELEPHANT IVORY

In light of the complexities related to the new regulations for African elephant ivory, the AIC recently published the position paper "The Preservation of Cultural Property with Respect to U.S. Government Regulation of African Elephant Ivory" (AIC 2015). Conservators Nina Owczarek, Terry Drayman-Weisser, Jean Portell, and I prepared the paper for AIC, which aims to present a balanced approach that supports elephant conservation efforts and respects laws that halt illegal trafficking of new raw and worked ivory while also advocating for protecting permitted (pre-Convention, CITES, and ESA documented) worked ivories of documented provenance from unnecessary destruction, destructive testing, and possible confiscation. It is our hope that the AIC can collaborate with the FWS, the American Alliance of Museums, the Association of Art Museum Directors, the Archaeological Institute of America, and other allied organizations to differentiate between legal and illegal elephant ivory artifacts. Certainly all conservators are encouraged to respect state, national, and international laws and regulations that apply to elephant ivory (and all endangered species generally) by stipulating that objects that need conservation have proper legal documentation (see US Fish and Wildlife Service 2016a, c). Some well-considered guidelines aiming to preserve legally documented ancient and antique worked ivories need not be in opposition to the efforts of federal regulatory agencies to staunch the current flow of new raw and worked ivory from Africa's rapidly diminishing elephant populations.

8. CONCLUSIONS

As elephant ivory is a highly valued material in many Asian countries, particularly China, an increased Chinese industrial and business presence in Africa has seen a recent corresponding increase in the ivory trade. Because both male and female African elephants have tusks, they are targeted by poachers. As both males and females are at risk, the future of the entire species is at risk. New regulations banning African elephant ivory commerce also affect the transit of worked ivories of any age and also impact artifacts with small inlays or ivory repairs. Conservators can inform themselves of current regulations and also assist curators, collection managers, and collectors in abiding by CITES and new US federal and state laws related to artifacts that incorporate animal parts, notably elephant ivory. An understanding of ivory features and identification methods and knowledge of ivory substitute materials inform the conservator's examination of these objects.

Some American museums have implemented a moratorium/ban on the purchase of elephant ivory, and some have implemented educational/outreach programs. Since 2009, the Smithsonian Institution's Museum Conservation Institute has co-organized and hosted an important recurring program to train US Immigration and Customs Enforcement agents about cultural heritage in transit. This program aims to assist in stemming the illicit trade of antiquities, art, and artifacts, including those made of regulated plant and animal parts, like elephant ivory.

Some museums have begun to contextualize elephant ivory artifacts by providing information about elephant species conservation. The Metropolitan Museum of Art included this text panel in their 2014 exhibition *Assyria to Iberia at the Dawn of the Classical Age*:

> The rise in ivory collecting during the Iron Age was catastrophic for Syrian elephants. By the end of the eighth century B.C., they had been hunted to extinction. Today, nearly three thousand years later, the desire for carved ivories and trinkets made from modern elephant ivory once again threaten the future of elephants. In some countries, African elephants are the target of poachers who sell modern ivory to be used in such carvings. It is crucial to conserve and to protect African elephants from suffering the same fate as the Iron Age elephants of Syria.

Art vendors are adapting in opposite ways; for its May 2015 sale of African, Pre-Columbian, and Oceanic Art, Sotheby's identifies African Lega and Luba objects as bone or hippo ivory; yet traditionally, these types of objects are often carved of elephant ivory. The stakes are high and clearly the path complicated, as it winds among elephant conservation laws and regulations, illegal trade and transit, and preservation of legal worked ivory art and artifacts.

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ADDENDUM (11/2017): The link provided for the reference, *Hornbeck, S. 2010 (revised 2016). Ivory: Identification and regulation of a precious material. Washington, DC: Smithsonian National Museum of African Art*, above is no longer active. A revised version of the document including updates on changes in legislation and additions to the selected bibliography can be found in the References section of the AIC wiki page on Ivory at http://www.conservation-wiki.com/wiki/Ivory