

Age and legality of ivory revealed by carbon-14 dating can fight poachers

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This African elephant has what are believed to be the biggest tusks among elephants at Kenya's Samburu National Reserve. Illegal poaching of some 30,000 elephants a year for their ivory tusks threatens the animals with extinction. University of Utah geochemists developed a new way to fight poaching of elephants, hippos, rhinos and other animals. Carbon-14 from 1950s and 1960s nuclear weapons tests was and still is deposited in animals' tusks or teeth, and those carbon-14 levels reveal the year an animal died, and thus whether the ivory was taken before or after international bans on ivory trading. Credit: Thure Cerling, University of Utah.

University of Utah researchers developed a new weapon to fight poachers who kill elephants, hippos, rhinos and other wildlife. By measuring radioactive carbon-14 deposited in tusks and teeth by open-air nuclear bomb tests, the method reveals the year an animal died, and thus whether the ivory was taken illegally.

"This could be used in specific cases of [ivory](#) seizures to determine when the ivory was obtained and thus whether it is legal," says geochemist Thure Cerling, senior author of a study about the new method. It was published online the week of July 1 in the journal *Proceedings of the National Academy of Sciences*.

"The dating method is affordable and accessible to government and [law enforcement agencies](#)," costing about \$500 per sample, says the study's first author, geochemist Kevin Uno, who did the research for his University of Utah Ph.D. thesis.

"It has immediate applications to fighting the illegal sale and trade of ivory that has led to the highest rate of poaching seen in decades," says Uno, now a [postdoctoral researcher](#) at Columbia University's Lamont-Doherty Earth Observatory.

Not only can the method help wildlife forensics to combat poaching, but "we've shown that you can use the signature in animal tissues left over from nuclear weapons testing in the atmosphere to study modern ecology and help us learn about fossil animals and how they lived," says Cerling, a distinguished professor of geology and geophysics, and biology at the University of Utah.

The method uses the "bomb curve," which is a graph – shaped roughly like an inverted "V" – showing changes in [carbon-14](#) levels in the atmosphere – and thus absorbed by [plants and animals](#) in the food chain. The [carbon-14](#) was formed in the atmosphere by U.S. and Soviet

atmospheric nuclear weapons tests in Nevada and Siberia from 1952 through 1962. Those levels peaked in the 1960s and have declined ever since but still are absorbed by and measurable in plant and animal tissues.

The study was funded by the National Science Foundation, the National Geographic Society and the University of Utah. Cerling and Uno conducted it with geologist Jay Quade, a former Utah doctoral student now at the University of Arizona; Daniel C. Fisher, University of Michigan, Ann Arbor; George Wittemyer, Colorado State University; Iain Douglas-Hamilton, founder of Save the Elephants; and Samuel Andanje, Patrick Omondi and Moses Litoroh, all of the Kenya Wildlife Service.

Ivory Trade Drives Elephant Slaughter

International agreements banned most trade of raw ivory from Asian elephants after 1975 and African elephants after 1989. In the United States, raw and worked African ivory (jewelry, figurines, gun and knife handles) is legal if it was imported before 1989 or, if worked ivory is imported after, it must be at least 100 years old.

Yet tons of illegal ivory still are sold because dealers claim the ivory was taken before the ban and there has been no test to prove them wrong – until now.

"With an accurate age of the ivory, we can verify if the trade is legal or not" when the age is combined with existing DNA analysis to determine if an elephant is from Africa or Asia, says Uno, who earned his University of Utah Ph.D. last year. "Currently 30,000 elephants a year are slaughtered for their tusks, so there is a desperate need to enforce the international trade ban and reduce demand."



After the death of their popular elephant Misha, Utah's Hogle Zoo agreed to donate one of her tusks to science. Credit: Hogle Zoo

Only 423,000 African elephants are left. Conservation groups say 70 percent of smuggled ivory goes to China. The United States is the next biggest illegal market. Rising ivory prices have drawn organized crime and spurred militias in Darfur, Uganda, Sudan and Somalia to kill elephants and sell tusks so they can buy guns.

How the Study Was Performed

Neutrons from the nuclear tests bombarded nitrogen – the atmosphere's most common gas – to turn some of it into carbon-14. Cosmic rays do that naturally at a low level, but open-air nuclear tests in the 1950s and 1960s sharply increased atmospheric, plant and animal carbon-14 levels, followed by a steady decline ever since.

The method in the study is a bit like telling a tree's age by its rings, but instead of counting rings, Cerling, Uno and colleagues measured carbon-14 levels at various points along the lengths of elephants' and hippos' tusks and teeth.

The conventional way of measuring carbon-14 is to wait for and count when the isotope decays radioactively. In the study, the researchers used accelerator mass spectrometry, or AMS, which requires 1,000 times less material for analysis – a big advantage when sampling fossils or small pieces of worked ivory, Cerling says.

In AMS, the material being analyzed is bombarded with cesium atoms, which sputters off carbon atoms so the ratio of carbon-14 to carbon-12 can be measured.

The researchers tested the accuracy of carbon-14 dating in 29 animal and plant tissues killed and collected on known dates from 1905 to 2008. The samples included elephant tusks and molars, hippo tusks and canine teeth, oryx horn, hair from monkeys and elephant tails, and some grasses collected in Kenya in 1962.

Samples came from museums in Africa and elsewhere, and from Amina, an elephant that died naturally in Kenya in 2006, and from Misha, an African elephant euthanized in 2008 due to declining health at Utah's Hogle Zoo in Salt Lake City.

The analysis revealed that various tissues that formed at the same time

have the same carbon-14 levels, and that grasses and the animals eating them had the same levels. By determining carbon-14 in these samples of known dates, the researchers now can measure carbon-14 levels in other ivory to determine its age, within about a year.

The four oldest samples – from animals died between 1905 and 1953 – had minimal carbon-14 because they died before atmospheric nuclear weapons tests. So the test can identify pre-1955 ivory by its low, pre-nuclear-test levels of carbon-14.

Cerling says the method can determine the year of death for any animal killed after 1955, identifying the time of the most recent tissue formation – at the base of a tusk or tooth, for example. The method is less precise for animals killed more recently; it can tell if an animal died between 2010 and 2013, but not more precisely.

It takes about 5,700 years for half of carbon-14 to decay radioactively. But the amount in Earth's atmosphere after the 1950s and 1960s bomb tests faded much more quickly because oceans and trees absorb carbon dioxide – including carbon-14 – from the atmosphere. So the method won't work for tusks or other tissues that grow after about 15 years from now, when atmospheric carbon-14 returns to pre-bomb levels.

Understanding Ancient and Modern Ecosystems

While the method's use against poaching is important, "the scientific part is the importance of understanding time in the formation of animal tissues and how diet and physiology is recorded in those tissues over time" as they grow, Cerling says.

Cerling says that will improve understanding of what prehistoric and modern animals ate over time, especially when combined with existing isotope analysis of ratios of carbon-13 to carbon-12 in teeth – data that

reveal whether animals ate diets based on tree and shrub leaves and fruits, or upon grasses and grazing animals.

So as part of the new study, the scientists also analyzed another 41 samples to determine the growth rates for tusks and teeth from elephants and hippos, and elephant tail hair, Cerling says.

Extrapolating the growth rates of tusks, teeth and hair to fossil or modern elephants and other animals "will help us improve the chronology of the diet history of an individual fossil or modern animal," Cerling says.

More information: Bomb-curve radiocarbon measurement of recent biologic tissues and applications to wildlife forensics and stable isotope (paleo)ecology, www.pnas.org/cgi/doi/10.1073/pnas.1302226110

Provided by University of Utah

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