environment360
Opinion, Analysis, Reporting & Debate

13 JAN 2014: **POINT/COUNTERPOINT**

POINT | COUNTERPOINT

The Case for De-Extinction: Why We Should Bring Back the Woolly Mammoth

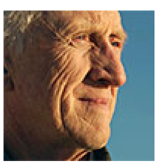
BY STEWART BRAND

With advances in genetic technology, we may someday be able to restore long-gone species like the woolly mammoth and the passenger pigeon. It's a goal worth pursuing, with real benefits for conservation and our sense of the natural world.

Sequenceable DNA can be recovered from museum specimens and some fossils of extinct species. That discovery in the 1980s set in motion the idea that it might be possible to bring some extinct animals back to life. The advent of ever-cheaper shotgun-sequencing of living genomes meant that the highly fragmented condition of "ancient DNA" was no barrier to reconstructing the whole genome of creatures long gone. Meanwhile, the rise of "synthetic biology" since 2000 is providing highly precise genome-editing tools.

Maybe we can edit long-dead genomes back to life. Maybe extinct species could walk the Earth again. Maybe they could once again thrive in the wild.

That prospect led to a nonprofit I cofounded with my wife, Ryan Phelan (she's the director; I write screeds like this), called Revive & Restore. Its mission is "to enhance biodiversity through genetic rescue of endangered and extinct species." Genetic rescue, we've realized, can have a wide range of applications. Genomic technology being developed to revive extinct species can be deployed to prevent extinction in some endangered species.


Stewart Brand

A major problem faced by species with small remnant populations is progressive inbreeding. They lose fecundity (often due to increasing homozygosity of deleterious genes), and they lack the genetic diversity needed to adapt robustly (many of their valuable gene variants, called "alleles," were lost when their population plummeted). The new genomic editing techniques should be able to restore heterozygosity pretty easily in living genomes. It may even be possible to revive "extinct alleles" from museum specimens or fossils to bring the remnant population back to the adaptive robustness it once had.

> If we succeed, the conservation story could shift from constant whining to high fives and new excitement.

Preventing extinction blurs over into reversing extinction in the emerging field of conservation genomics. If extinct alleles can be revived, how about whole extinct genomes? All you might need is to patch into the living genome of the extinct animal's closest living relative. For the passenger pigeon, it would be the band-tailed pigeon; for the woolly mammoth, the Asian elephant. (I'll take those two, which Revive & Restore is focusing on, as my examples. The same could be said for the great auk, the Carolina parakeet, the ivory-billed woodpecker, the Caribbean monk seal, the Xerces blue butterfly, the heath hen, the thylacine (Tasmanian tiger), the gastric-brooding frog, the New Zealand moa, the Hawaiian o'o, etc. — there are hundreds of candidates.)

But why do it? What's the point of bringing back some pigeons that have been gone for a century, or some hairy elephants that disappeared four millennia ago? Well, what's the point of protecting unhairy elephants in Africa or over-specialized pandas in China or dangerous polar bears in the Arctic, or any of the endangered species we spend so much money and angst on preserving?

We protect endangered species, conservationists retort (and most of the public agrees), in order to preserve the richest biodiversity we can, to retain creatures that have important ecological roles, or that

The Case Against De-Extinction: It's a Fascinating but Dumb Idea

BY PAUL R. EHRLICH

Even if reviving extinct species is practical, it's an awful idea. It would take resources away from saving endangered species and their habitats and would divert us from the critical work needed to protect the planet.

Read the Counterpoint article

CONNECT WITH YALE E360
Subscribe to Newsletter
Follow us on Twitter
Like us on Facebook

MORE FROM E360

In Galápagos, An Insidious Threat to Darwin's Finches
The birds that have come to be known as Darwin's finches have long intrigued students of evolution. But now, **Elizabeth Kolbert** reports, a parasitic fly introduced to the Galápagos Islands is threatening the future of one or more of these iconic finch species.
READ MORE

Michael Pollan on the Links Between Biodiversity and Health
Author Michael Pollan has often written about people's relationship to the natural world. In a *Yale Environment 360* interview, he talks about researching his latest book and what he learned about the connections between ecology and human health.
READ MORE

As Tigers Near Extinction, A Last-Ditch Strategy Emerges
In the past century, populations of wild tigers have plummeted from 100,000 to 3,500. Now the World Bank and conservationists have launched an eleventh-hour effort to save this great predator, focusing on reining in the black market for tiger parts and ending the destruction of tiger habitat.
READ MORE

people love, or as emblems to protect whole endangered ecosystems. We protect them to learn the science to protect them better. We protect them to undo harm that humans have caused.

COUNTERPOINT

De-Extinction is a Fascinating Concept but a Very Dumb Idea
*Noted biologist **Paul R. Ehrlich** argues that attempting to restore extinct species would take resources away from saving endangered species and habitats and would divert us from the critical work needed to protect the planet.*
Read More

All those reasons apply to bringing back extinct species, plus some — such as the pure thrill of the prospect of herds of mammoths bringing tusker wisdom back to the far north, or clouds of passenger pigeons once again darkening the sun. It would be a reframing of possibilities as momentous as landing humans on the moon was (at a tiny fraction of the cost). Conservation biology would leap to the forefront of genetic science. The conservation story could shift from negative to positive, from constant whining and guilt-tripping to high fives and new excitement.

Passenger pigeons were North America's most iconic extinction. When they were slaughtered from billions to zero in the late 19th century, we caught on that the same was about to happen to the American bison, and the protection of endangered species became an established idea and practice. How fine it would be to reverse the founding human mistake that inspired modern conservation. It would mean that conservation biology has come full circle.

Aldo Leopold described the ecological role of passenger pigeons as if they were a forest fire: "Yearly the feathered tempest roared up, down, and across the continent, sucking up the laden fruits of forest and prairie, burning them in a traveling blast of life." Their old habitat, the renowned Eastern deciduous forest, is largely back, perhaps needing the return of an important bird species that only the oldest trees remember. (The other great needed revival is the American chestnut, once one-quarter of the forest trees, now coming back strong thanks to genetic techniques and the efforts of The American Chestnut Foundation.)

The Eastern forest that was the habitat of the passenger pigeon is back, needing the return of a key bird species.

The woolly mammoth was one of the most important keystone species of all, according to Sergey Zimov, the Russian scientist who founded "Pleistocene Park" in northern Siberia. When the herds of northern megaherbivores were killed off by humans ten millennia ago, Zimov says, the largest biome on earth, called the "mammoth steppe," converted from grassland to boreal forest and tundra. In these days of global warming, thawing tundra is releasing greenhouse gases, whereas grassland fixes carbon. Zimov is currently restoring grassland in the far north with muskoxes, wisents, and Yakutian horses. He is waiting patiently for mammoths. "We knock down the trees with military tanks, but they make no dung."

The idea of plausible de-extinction entered the public discourse last March, when Ryan and I organized a "TEDxDeExtinction" at the National Geographic Society in Washington, D.C., featuring 25 scientists speaking on the subject. It was widely reported and discussed. Debate was encouraged, and the subject duly became "controversial." Arguments against the idea fell into three patterns, depending on who was voicing the doubts — the general public, professional conservationists, or people with biotech savvy.

Public worries centered on what would happen when formerly extinct animals are reintroduced to the wild. They might run destructively amok like kudzu! Or, surely they could not survive because the world has changed so much since their time; with their habitat gone, all they could hope for is a life in zoos, and that would be pathetic. Nature, in other words, is widely seen as either hopelessly fragile or already completely broken.

Flying Puffin/Wikimedia Commons
The woolly mammoth went extinct in its main range about 10,000 years ago.

Conservationists voiced few such concerns because they know how common it is, these decades, to successfully reintroduce animals to the wild after a long absence, either from other regions or from captive breeding programs. The return of wolves to Yellowstone National Park after an absence of 70 years is regarded as one of the great recent conservation coups. Black-footed ferrets are back on the U.S. high plains. Beavers are being reintroduced all over Europe, and wolves are reintroducing themselves there, thanks to the widespread reforesting of abandoned farmland. The IUCN's Reintroduction Specialist Group puts out frequent reports chronicling scores of case studies worldwide. Nature is not broken, nor, apart from ocean islands and some fresh water systems, is it particularly fragile.

Two things worry conservation professionals. One is that de-extinction would be so expensive and high-visibility that it would divert money and attention from crucial programs to protect endangered species. An unsigned editorial in Scientific American concluded: "A costly and flamboyant project to resuscitate extinct flora and fauna in the name of conservation looks irresponsible: Should we resurrect the mammoth only to let elephants go under? Of course not."

In what universe, I have to wonder, would people newly excited about mammoths become suddenly indifferent to imperiled elephants? If there really is a zero-sum money trade-off in these matters, we could assume that the $35 million-plus spent on the captive breeding and reintroduction of California condors must have drained other conservation projects in the state. That hasn't happened. More likely is that de-extinction will attract significant new sources of funding and interest for conservation.

It is likely that de-extinction will attract significant new sources of funding and interest for conservation.

The other worry among conservationists is that the great warning "EXTINCTION IS FOREVER!" will lose its sting, and politicians will stop funding the protection of endangered species with the argument: "It's okay if the whatevers go extinct; you can bring them back later." Exactly the same fear was raised 35 years ago when Oliver Ryder at the San Diego Zoo founded the Frozen Zoo to cryopreserve cells and DNA from endangered animals. Over a thousand species have now been preserved there, to the great benefit of research on the protection of endangered species and with no apparent harm to political support for protecting them. De-extinction is likely to bring new knowledge and new public involvement in preventing extinction.

The best arguments against de-extinction, I think, are the most technical ones, focused on the extreme complexity of resurrecting extinct genomes. It hasn't been done yet. Maybe it's impossible.

Whole genomes — both nuclear and mitochondrial "ancient-DNA" — have been shotgun-sequenced and reassembled from eight extinct species so far. The woolly mammoth is one of them; early next year the passenger pigeon will be the ninth. But how different are their genomes from their relatives, the Asian elephant and band-tailed pigeon? Can the important genes to transfer from the extinct genome to a living genome be identified? How about the non-coding regulatory genes? What if there are an overwhelming number of genes that have to be transferred? Research on those questions is now under way. Encouraging answers are not guaranteed.

Then there's the task of converting gene data into living genes. This is done routinely in synthetic biology these days, usually in microbes but increasingly with vertebrates such as mice. Working with induced pluripotent stem cells (thanks to Nobel Prize winner Shinya Yamanaka) eases the task, and the "Multiplex Automated Genomic Engineering" machine developed by Harvard geneticist George Church can write many genes at once. But shifting a whole suite of extinct traits into a living genome has yet to occur.

And how do you then get to a living animal? With mammals you'll have to do interspecies cloning — somatic-cell nuclear transfer of the reconstituted genome of the extinct species into the enucleated egg of a surrogate mother and then implanting of the early-stage embryo in her uterus. This extremely tricky process has been proved only once, when a Javan banteng calf (using DNA from the Frozen Zoo) was successfully birthed from a domestic cow. That approach can't work with birds, because their embryos never implant; they move constantly down the oviduct. There is a technique being developed at the Roslin Institute in Scotland which might serve, though. It involves creating chimeric parent birds with the gonads of the extinct birds, capable of fertilizing and laying eggs of the extinct species. So far the only proof of the method is a chimeric duck that successfully produced chicken sperm and fathered a baby chick.

If it looks like a passenger pigeon and flies like one, is it the original bird?

The tools of synthetic biology are advancing, these days, several times more rapidly than Moore's Law. What seems impossible one year is merely expensive a couple years later and routine soon after that. Technical criticism of the processes of de-extinction will often be dead right, but not necessarily for long.

The final question will be whether the resurrected animal is really the extinct animal. If it looks like a passenger pigeon and flies like one, is it the original bird? We don't have any living originals to compare it with. (The crucial experiment will be to convert a band-tailed pigeon, using the same methods, into a known living bird such as a mourning dove.) If it's mostly passenger pigeon, is that good enough? Kent Redford, former chief scientist for the Wildlife Conservation Society, points out that the American bisons we avidly protect are only mostly bison, with quite a lot of cattle genes. Suppose we duplicate the passenger pigeon genome in its entirety. Is the genome the bird? Is your identical twin a human?

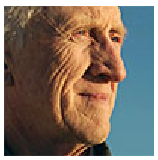
To me, one of the greatest attractions of bringing back extinct species is how long it will take. Even if all goes well, getting passenger pigeons back (along with other species if the techniques work) will take decades. For a baby female woolly mammoth to grow up and have a daughter takes twenty years. Getting herds back to the subarctic, grazing the mammoth steppe back into existence, will be a century-scale project.

Children growing up in such a century might have a view of the relation of humans with nature that is not tragic, for a change.

COUNTERPOINT

Read Paul R. Ehrlich's case against de-extinction

ABOUT THE AUTHOR



Stewart Brand is the co-founder of The Long Now Foundation and of its de-extinction project, "Revive & Restore." He created and edited the *Whole Earth Catalog*, and has written a number of books, the most recent of which is titled *Whole Earth Discipline*. Brand studied biology at Stanford University, with Paul R. Ehrlich as his field work advisor.

COMMENTS

Email Facebook Twitter Stumble Upon Digg Share g+1