

What is De-extinction?



By Joaquin Flores

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Hilltown Cooperative Charter Public School

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De-extinction is something you might have heard of on the radio or in a newspaper somewhere. But what is de-extinction? De-extinction is the controversial practice of bringing back extinct species and rewilding them (the process of putting a species back in its natural habitat), generally through genetic modification. De-extinction has picked up steam in the past year, and has created a whole new possibility in the realm of wildlife conservation. But before delving into the world of de-extinction, it is best to look at its origins.

The concept of de-extinction originated in the minds of authors such as Michael Crichton and John Brosnan in their respective books, Jurassic Park and Carnosaur. These tales were intended to warn people about the dangers of de-extinction, but ironically inspired people to do just that—re-create extinct animals. In 2003, a team of Spanish scientists attempted to bring back the Pyrenean ibex, a type of Spanish mountain goat, from extinction. Although a living specimen was produced, it died seven minutes later from lung failure. This was the first de-extinction attempt ever (Wikipedia). In 2012 Ryan Phelan and Stewart Brand founded Revive and Restore, a project within the Long Now Foundation with the intention to increase biodiversity using techniques used by de-extinction. Revive and Restore is now currently working on bringing back the passenger pigeon, a bird that was hunted to extinction in 1914 (Revive and Restore).



Pyrenean Ibex, *Capra pyrenaica pyrenaica*

While de-extinction is an exciting prospect, it is easier said than done, with most of the process being extensive. As an example of de-extinction I will use the Great Passenger Pigeon Comeback, a project by Revive and Restore to bring back the passenger pigeon. The first step in bringing back the species is to find specimens. When the Great Passenger Pigeon Comeback started, sixty-five passenger pigeon specimens, fifty-three tissue samples, and nine bone samples were processed; 34 of the specimens contained enough DNA to sequence (Revive and Restore). In addition to the passenger pigeon, another pigeon's DNA was extracted—the band-tailed pigeon, the closest living relative of the passenger pigeon. The band-tailed pigeon genome will be used as a reference for the passenger pigeon genome when it is sequenced. The reason the band-tailed pigeon needs to be used for reference is that passenger pigeons have ancient DNA that has degraded over the years and become jumbled and clumped. The band-tailed pigeon DNA that was used was fresh, and so it hadn't degraded at all. Beth Shapiro, one of the scientists working on the sequencing of the passenger pigeon, hopes to publish an analysis of the genome by September 1st, the 100th anniversary of the passenger pigeon's death (*New York Times*).

After the genome is sequenced, the next step is to inscribe the genome into a living cell. This is done by culturing germ cells from band-tailed pigeons. Cell culturing is the process of growing living tissue on a petri dish. Bird cells are especially difficult to culture as they strongly prefer not to exist outside of the bird's body. However, it is just a matter of trial and error- eventually they will get it right (*New York Times*).

If the germ cell is successfully cultured, scientists will begin modifying its genetic code to make it resemble a passenger pigeon. This is done using a machine called the "Multiplex Automated Genomic Engineering machine (MAGE)," or "evolution machine," developed by George Church. The evolution machine is designed to mutate a genome (in this case the band-tailed pigeon's) until it resembles the intended genome (in this case, the passenger pigeon's). Once this is done, the germ cells need to be injected into an egg. Once this is done the germ cells will imbed themselves into the band-tailed pigeons embryo. When the chick hatches, the offspring will be identical to a band tailed pigeon except that the sex cells are those of a passenger pigeons. These are known as chimeras (from the Middle English for "wild fantasy.") When two of these chimeras breed, they will produce a passenger pigeon- or at least a passenger pigeon-band tailed pigeon hybrid (New York Times).

Once the passenger pigeons hatch, environmental and developmental biologists will take over the process. Chicks imitate their parents, so how will band tailed pigeons be trained to raise them? Will the band-tailed pigeons accept the passenger pigeon as one of its own? Even though these birds are genetically similar, there are several large differences. Band-tailed pigeons are western birds that migrate

north and south annually, while passenger pigeons are eastern birds and have no known fixed migration patterns. Revive and Restore plans to counter these problems by altering a group of band-tailed pigeon's diet, migration patterns and habitat to ease the band-tailed/passenger gap. "Eventually," Novak said, "we'll have band-tailed pigeons that are faux-passenger-pigeon parents." As unlikely as this sounds, there is a strong precedent; surrogate species have been used extensively in pigeon breeding" (*New York Times*).

In addition to bringing back extinct species, de-extinction techniques could be used in a variety of ways. One of the things that de-extinction could be used for is to increase biodiversity for endangered species such as the California condor or the northern white rhinoceros. When a species becomes endangered, the gene pool, or genetic diversity of the species is shrunk to a gene puddle. MAGE could counteract these effects by creating small genetic mutations in the creature's DNA. The technology could also be used to counteract diseases in animals such as the white nose fungus in north American bats. Some European bats are seemingly immune to the disease. If the gene that causes the immunity is discovered, it could be put into North American bats that are suffering because of it.

A great many animals have gone extinct in the past 10,000 years, many of which have been because of the sixth mass extinction. A mass extinction is an extinction that wiped out over half of life on earth. Because there are so many extinct animals, and a limited budget for these things, only a few animals could originally be selected for de-extinction. Here I have shared with you a few projects being worked on right now. (For Revive and Restore's full list of candidate animals, go to longnow.org/revive/candidates.)

One of the biggest projects currently in de-extinction is the woolly mammoth. At least three different teams are currently working to bring back this creature, or at least a furry Asian elephant. These iconic creatures have found their way into the hearts of many and would be a sight to see walking around in the tundras of Russia and America.

Woolly mammoths lived up until about 2,500 years ago. Before then mammoths lived in almost every continent. The woolly mammoth dominated the most massive territory—the mammoth steppe. The mammoth steppe was a vast ecosystem that stretched across most of Europe and about half of Asia. The mammoth steppe was a vast shrubland with sparse trees maintained by larger mammals such as bison and mammoths. no one knows just how all the mammoths—and most of the megafauna died out. Some believe it to be climate change. Some believe it to be diseases. But the most likely reason is that we hunted them to extinction. The expansion of humans across Europe, Asia, and North America corresponds with the extinction of megafauna across the world. While this theory has yet to be proven, it seems the most likely explanation.

There are at least three different woolly mammoth revival projects currently in the works, but the most likely one seems to be a team of Russian and Japanese scientists working on bringing the creature back. The catch about this woolly mammoth though is that it isn't exactly a woolly mammoth (*NPR*). The resulting creature will be a cross between a woolly mammoth and an Indian elephant. The objective of the project isn't to create a perfect woolly mammoth, but to create an animal that will fill its role. These animals will be kept in Pleistocene park, a wildlife reserve in Siberia intent on re-creating the mammoth steppe.

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Daniel Fisher, University of Michigan

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Another species that is being brought back is the passenger pigeon. These majestic birds were the most abundant of all birds in north America, and possibly in the world. To put it in perspective, a naturalist estimated that in a single flock there may have been up to 3,717,120,000 passenger pigeons. Currently there are about 260,000,000 rock pigeons in the world. That ratio is about one to fourteen. The ratio for all the passenger pigeons would be more like one to nineteen. The birds were so abundant that they are known as a “feathered river across the sky.” If these birds were so abundant, what had happened that had driven them all to extinction? (*New York Times*).

Humans happened. Like the American buffalo, passenger pigeons were hunted by the thousands and their meat was sold by the ton. They were so commonplace that, like the buffalos, no one thought that they could possibly go extinct. In later years groups of men traveled by train so that passenger pigeons were constantly being attacked. In 1900, the last wild passenger pigeon was shot by a boy with a BB gun. In 1902, a captive-bred passenger pigeon named Martha was sent to the Cincinnati zoo. By 1910 she became the last passenger pigeon known. On September first, 1914 Martha died. Her body was frozen in a block of ice and shipped to the Smithsonian, where she will be back on display for the 100th anniversary of the passenger pigeon's extinction.

Revive and Restore has initiated a project to revive the passenger pigeon and reintroduce them into New England forests by 2025. This is the most promising of all the current de-extinction projects, and has received the most hype. Almost all genomic research is done, except for the bioinformatics, in which research is currently under way. One of the problems is that passenger pigeons might still be hunted, as females can be easily mistaken as mourning doves. Another problem would be that if the passenger pigeons became abundant as they were, they would soil everything. This problem fixes itself, at least temporarily, because passenger pigeons would take hundreds of years, if not thousands to grow to its previous sky-blackening numbers.



passenger pigeon, *Ectopistes Migratorius*

Last but not least on the revival list is an Australian animal called the gastric brooding frog. These frogs had a unique ability. When these animals lay eggs, they swallow them and turn their stomach into an uterus. These frogs are the only known species that can change the function of one organ into another. This could be potentially revolutionary for medical sciences if it could be revived.



The gastric brooding frog, *Rheobatrachus silus*

De-extinction, like any genetic modification project, has a lot of controversy surrounding it. The internet is swimming with articles proclaiming the evils of de-extinction, and just as many aggressively dismissing these worries.

The disadvantages surrounding de-extinction are fairly numerous and well based, with complaints about things such as money being diverted from other conservation methods and that the animals could never survive in the changing environment of the twenty-first century. Another argument made against de-extinction are that if animals could be brought back from extinction, then people would stop caring if something went extinct after all, you could just bring it back later, right? Yet another argument against de-extinction is that it could destroy ecosystems that evolved after the animals went extinct.

The rebuttals for de-extinction are equally as convincing and are just as numerous as the arguments against it. The rebuttal for the money problem is that it may also bring in other donors for conservation that were not there already, and that it doesn't use the same monetary source as conservation movements. The rebuttal against the inability to survive in modern-day habitats is equally convincing. One of them is that the wolf, which was locally extinct in Yellowstone National Park for about seventy years, has greatly improved biodiversity in the park (*Ted Talks*).

De-extinction is a fast-evolving science that creates as many questions as it gives answers. The animals participating in de-extinction are fascinating, and the questions surrounding it are intriguing. This change will be revolutionary to the way animals are brought back into the wild and will bring back incredible creatures from the past.

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