

Bringing back extinct species – The Good

The ability to read, edit, and even create new DNA in recent years has expanded the horizons of species conservation from traditional ‘protect, conserve, restore’ approaches to a new, exciting one - that of species *revival*. Additionally, bringing back extinct species is a great intellectual exercise in understanding evolution and how these organisms might have lived and influenced their habitats. De-extinction can also address several global health issues, and perhaps even help prevent the next mass extinction. Lastly, many argue that de-extinction is our moral imperative as humans, as a large number of extinctions are a consequence of our actions.

De-extinction and Conservation: Human activity has permeated more and more areas of our planet since the last century, bringing along a concordant decrease in biodiversity¹. De-extinction offers an easy solution to the conservation issues that this has raised. Firstly, de-extinction of lost alleles can be used to prevent genetic drift driven extinction of small, extant populations. As relevant examples, lost diversity in existing species, such as Mauritius Kestrel bird, black-footed ferrets, and white rhinos, can be re-engineered back in by identifying the lost genetic diversity from closely related populations. Dr. Beth Shapiro sums it up as follows: “*Why not provide populations a little bit of genomic assistance so they can survive in a world that is changing too quickly for natural evolutionary processes to keep up*”². This argument also extends to protecting species that are close to extinction because of a genetic predisposition for early death, such as the Tasmanian devils, which have transmissible, genetically identical facial cancer. Secondly, many recently extinct species like the thylacine and the ivory-billed woodpecker were driven to extinction because of unchecked hunting and destruction of habitats. These habitats have since become more welcoming and secure, and bringing back these *recently extinct* inhabitants is expected to increase the biodiversity and health of these habitats, instead of being detrimental in any way. Thirdly, human actions have sometimes unknowingly disrupted ecological equilibrium, as was the case with the dodo bird and the Tambalacoque tree³. Extinction of organisms that have coevolved with keystone ecosystem species is a major cause of concern in habitat conservation efforts. Bringing back these species will ensure the survival of an entire damaged habitat.

De-extinction and Extinction!: Carl Zimmer, a major vocalist for de-extinction, has raised concern about the increasing *rate* at which species are going extinct as a consequence of human activities. The last mass extinction occurred 65 million years ago, and wiped out 76% of the species. If we look at extinction rates of species in nature, per 1000 species per 1000 years, early fossil records indicate a general loss of 0.1-1 species. Currently this number stands at ~100, and future projections range from 1,000-11,000⁴. This rapid loss of biodiversity can destroy ecosystems as a whole in one fell swoop, threatening not just niche habitats, but the balance and well-being of human societies as well. De-extinction is one way by which we can slow the pace of destruction of species biodiversity around us, thereby ensuring our own long-term survival as a species.

Modern medicine: A genome is a mere template, and only by bringing back an extinct species to life can we begin to fathom the regulatory mechanisms vital to that organism’s survival. A comparison of these genetic features in the revived species with human orthologs can provide insight into, for example, the features or protein products that are advantageous for surviving in cold environments (as in the mammoth)⁵. We might also be able to learn about the influence of these extinct species on changes in their immediate habitat, resulting in longer-term impacts on evolution and bio-diversity. These questions remain mere speculations until we have the ability to actually study these organisms ‘live in action’.

Climate change: The tundra’s permafrost holds massive reserves of greenhouse gases, and melting permafrost threatens to accelerate climate change by releasing these gases at an increased rate. The Mammoth Steppe Ecosystem Restoration program hopes to re-introduce mammoths (after bringing them back) in the tundra as grazers. The work of Dr. Sergey Zimov has shown that this can convert the tundra back to grasslands, which then help insulate permafrost and sequester atmospheric carbon⁶.

Bringing back extinct species – The Bad

The limit of DNA survival is 1 million years. With this large timeframe covering the set of extinct species that can be brought back, the arguments against de-extinction are understandably complex. The following points discuss concerns about our scientific ability to successfully reconstruct an extinct species' genome, the negative impact of this technology on human behavior vis-à-vis climate change and existing conservation efforts, the risks involved with re-introduction of extinct species in habitats that have since changed, and our capability to establish self-sustaining populations after so much financial and intellectual investment in de-extinction efforts⁷.

Genomic challenges: Current methods for recreating most ancient genomes (ex. The mammoth) rely on a fusion model. The ancient DNA is often highly fragmented, in poor condition, and contaminated by bacteria and human handling. Thus, while reconstructing the ancient genome is difficult solely using this fragmented input, it can be done using a near-relative surrogate organism's DNA as a backbone into which the fragments can be sliced. However, the role of epigenetics and non-coding DNA in early development and the role of maternal care in an infant's development cannot be ignored in any species. Thus, using a close species as surrogates, for example an Asian elephant, is not going to emulate the specific environmental and epigenetic influences a mammoth baby would have had in normal development, thousands of years ago. The 'mammoth' you get at the end of this long-drawn effort will be a result of interactions with the host animal's environment, not a 'pure' mammoth baby⁸.

Furthermore, during the creation of the 'fusion genome' using the extant species' DNA as backbone, we might not necessarily have any insights on the location of genes specific to the extinct organism, and addition of big genomic fragments without any idea about their form and function can lead to unpredictable outcomes, perhaps a totally novel organism with adverse impact on existing biomes (like a new vector for pathogens). Lastly, this approach relies on CRISPR, which is a highly specific gene-editing tool. Nevertheless, the specificity of the approach breaks down to the use of appropriate single-guideRNAs that have minimal off-targets⁹. Recent concerns with the use of CRISPR to 'cut out' the HIV virus in patients, which backfired when the scar excision sites proved to be more beneficial for the virus to re-insert and proliferate, also highlights how there is still more to learn about the exact, targetable nature of CRISPR and its downstream effects.

The demise of caring: If we were to take on de-extinction as regular practice, we put ourselves in a position of being able to turn back the genetic clock as far back as 1 million years ago. The unprecedented ability to bring back species may further fuel apathetic lifestyles with no regard for protection of species. The situation can easily degenerate into a state where we continue to overuse resources and stop caring about climate change, presuming that de-extinction will handle any negative consequences of our actions. This general 'hail the savior' outlook to de-extinction, while also naïve and short-sighted, completely ignores the extra effort that will *still* need to go into sustaining these 'retrieved' species, perhaps at the cost of existing conservation and climate change awareness efforts.

Establishment of self-sustaining populations: Bringing back a single member of the species is not equivalent to its de-extinction per se. For example, the passenger pigeons were a social population, and each pigeon only laid 1 egg. As David Ehrenfeld puts it, "*the more they were, the better they did*" (also called the Allee Effect). Furthermore, the habitats of these extinct species have since changed, and reintroduction of these species to a habitat that has since evolved without them leads to tenuous survival outcomes. Reviving extinct species will still remain a conservation dependent task to keep them going. The re-introduction of these species may also lead them to act as invasive species, similar to the cases of the American chestnut fungus and the West Nile virus. This has already generated a lot of hue and cry from conservationists, who have already been fighting for funding and public attention to conserve extant threatened species, and who will have to then divert attention to the preservation of these revived species with less clearer positive outcomes for habitat health and biodiversity.

References (*The Ugly*)

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If nothing else, from an etymological viewpoint, we will have to revisit the definition for extinction regardless of whether we favor or oppose de-extinction.
