# The moral implications of de-extinction

*Return of the aurochs and woolly mammoth*

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## *Abstract*

De-extinction is an umbrella term for three methods that aim to bring back extinct species: back-breeding, cloning and genetic engineering. This thesis is dedicated to answering the question whether or not de-extinction can be justified as a conservation strategy. Two de-extinction projects will serve as case studies: the project back-breeding the aurochs and genetically engineering the woolly mammoth. Both aim to bring back species that can fulfil the ecological niche of the extinct species, thus serving as functional proxies. De-extinction characterizes a more interventionist approach towards nature conservation, and it is met with different responses from conservationists. Conservationists have different ideas about the values that should be protected in nature conservation, such as the value of biodiversity, naturalness, wildness, ecosystem services and the autonomy of nature. This is likely going to affect whether or not one is convinced by the moral problems with de-extinction. Important moral concerns that have been put forward, are that de-extinction is merely a technological fix to the problem of species extinctions, that it can only create artefacts, violates animal welfare and rights, creates a moral hazard, is inherently risky and that it is not in line with the proper attitude to have towards the natural world. Importantly, these concerns do not apply in a similar extent to different de-extinction projects. Differences between projects mean that some might be more problematic than others. The woolly mammoth de-extinction is different from the aurochs project because it uses genetic engineering rather than back-breeding, the feasibility for release into the wild is less likely for the woolly mammoth, and because concerns with animal welfare and rights are more serious. This makes the project more hubristic, more prone to the concern of creating artefacts, less likely to succeed and overall morally more problematic. It is concluded, as a result, that de-extinction of the woolly mammoth cannot be ethically justified as a conservation strategy. With regards to the aurochs, there are less moral problems. But, unless there are convincing arguments that no extant cattle species can be used instead, there does not seem to be a strong ethical imperative to for its de-extinction either.

# 1 Introduction

## *1.1 From science fiction to science*

In 1990, Michael Crichton wrote the novel *Jurassic Park*. In this science-fiction story, a population of dinosaurs is brought back through genetic engineering. Dinosaur DNA is obtained from blood of insects that have been preserved in amber, and the gaps in the damaged DNA are filled with DNA of other species. A population of dinosaurs is created to populate a theme park on an island off the coast of Costa Rica. The action begins as soon as the dinosaurs unexpectedly begin to reproduce and escape the island, and turn on their creators.[1]

Three decades after Crichton's novel was published, George Church, a professor of genetics at Harvard Medical School, is leading a group of researchers who are working on resurrecting the woolly mammoth.[2] They are planning on genetically engineering the genome of the Asian elephant to contain more mammoth genes, in order to create a cold-tolerant version of the Asian elephant that can survive in the woolly mammoth's former habitat.[3] George Church's project is part of a new scientific field called de-extinction, concerned with creating organisms that belong to extinct species, or at least resemble them to a great extent.[4]

There seems to be a general consensus that we have a duty to prevent extinctions from happening. De-extinction, however, takes this idea a step further. Do we also have an obligation to bring extinct species back to life?

## *1.2 Conservation in the Anthropocene*

Preston describes how for a long time, the focus of nature conservation was to preserve nature just as it was. Millions of years of evolution and biological history had given moral significance to the natural environment, and the fact that it had evolved without humans for most of evolutionary time added to this value. Environmental writer Aldo Leopold was

[1] Crichton, 1990
[2] Shapiro, 2015a
[3] Campbell & Whittle, 2017
[4] Martinelli, Oksanen & Siipi, 2014

one of proponents of the idea that untouched nature was the most desirable kind of nature. Before him, others like John Muir also advanced this idea. The more independent of humans, the more valuable nature was considered to be, and as a result, principles of non-interference and restraint were at the core of conservation thinking.[5]

This Romantic preference for pristine nature and wilderness has been critiqued for many reasons over the past decades, not in the least since it ignored the indigenous presence in the areas that were considered pristine.[6] In addition, the realization of the extent to which the human species has transformed the planet has led some to believe that there is no pristine nature left.[5] In 2000, Crutzen & Stoermer suggested that human impact on the atmosphere, hydrosphere and geosphere is so immense, that our species can be recognized as a global geophysical force.[7] Whereas the atmosphere saw a rise in the amount of greenhouse gases and the geosphere an immense amount of soil erosion, the biosphere is currently undergoing what has been called the sixth mass extinction of species.[8] When looking back at the earth's sediments, Crutzen & Stoermer believe that geologists would be able to distinguish a new geological time period. In their essay they proposed to call this period the "Anthropocene".[7] Despite not being the first to coin such an idea, according to Preston, Crutzen & Stoermer's essay "marked the beginning of a radical shift in our species' self-image," by making us more aware of the effect we could have on the planet.[9]

Keulartz & Bovenkerk describe how the realization of the magnitude of our influence on the planet changed the conservation game.[8] A debate about conservation values began, starting with the essay 'The death of environmentalism', written by Michael Shellenerger & Ted Nordhau.[10] This essay, in which the authors argue that nature preservation is outdated and must make way for something new, was the start of a movement known as ecomodernism.[8] Ten years later, the Ecomodernist Manifesto came out, in which the most important principles of the ecomodernist movement were described.[11] Within this movement, the focus is less on the protection of biodiversity for its own sake, and more about creating a resilient natural environment that can provide ecosystem services for human beings.[8] Ecomodernists departs from traditional environmentalism, amongst others in the sense that they encourage interference with natural systems. [8]

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[5] Preston, 2018
[6] Cronon, 1996; Preston, 2018
[7] Crutzen & Stoermer, 2000
[8] Keulartz & Bovenkerk, 2016
[9] Preston, 2018: 163
[10] Shellenerger & Nordhau 2009
[11] Boersma, 2021

## *1.3 De-extinction*

De-extinction is a technique which would, as a conservation practise, characterize a more interventionist approach towards nature. De-extinction is an umbrella term for three methods that aim to bring back extinct species: back-breeding, cloning and genetic engineering.[12]

### *Back-breeding*

Campbell & Whittle describe how the earliest de-extinction attempt was carried out by the Heck brothers in the 1920s. The two zoo directors, Heinz and Lutz Heck, came up with the plan to bring back the aurochs, the ancestor of modern cattle that went extinct in 1627. Over centuries, the aurochs had been selectively bred to become smaller, more obedient, and have less dangerous horns. Heinz and Lutz, motivated by a fascination for animal breeding and ancient Germanic culture, wanted to reverse this domestication process. Their idea was that wild ancestral characteristics could still be found in the domestic cattle breeds that descended from the aurochs, and that these were spread among them. Working in a time before the discovery of DNA, the brothers bred those individuals that resembled the aurochs most, in this way trying to create organisms with an increasing amount of ancestral traits.[13] Their plan caught the interest of the Nazi government because of its focus on racial purity and its goal to restore the Germanic landscape, who started funding them.[14] In the early 1930s both brothers claimed success: the cattle had bigger horns, were larger and had become increasingly obedient, bordering on dangerous. Whereas Lutz' back-bred cattle did not survive the war, Heinz' cattle did and became known as *Heck cattle*. In 1983, a population of Heck cattle was released in the Oostvaardersplassen as part of one of the first rewilding experiments.[13]

Beth Shapiro defines back-breeding as the "use of selective breeding to resurrect specific ancestral traits within populations of living organisms."[15] These living populations can be close relatives, descendants or hybrid forms of the extinct species.[12] Since the Heck brothers' de-extinction efforts, more advanced methods of back-breeding have been developed.[13] The genome of the aurochs has been sequenced and is being compared to the genomes of extant cattle breeds, with the goal of determining the differences.[13] This knowledge can be used when back-breeding, "using DNA analysis as a yardstick to measure the progress."[16] Unlike other de-extinction techniques, back-breeding does not

[12] IUSCN SSC, 2016
[13] Campbell & Whittle, 2017
[14] Kolbert, 2012; Campbell & Whittle, 2017
[15] Shapiro, 2017: 997
[16] Goderie et al., 2013: 119

involve direct manipulation of genetic material.[12] As a result, there is little control over which traits are retained.[12] The aurochs are not the only extinct species that scientists are trying to bring back via this method. For example, the plains zebra is being selectively bred to bring back the quagga, a subspecies of the plains zebra that went extinct.[17]

## *Cloning*

Somatic cell nuclear transfer (SCNT), or cloning, is a technique that can be used to create genetic copies of organisms.[18] The first successful cloning was carried out in the 1990s, when the sheep Dolly was created.[17] For the purposes of de-extinction, interspecies cloning would be carried out, which means that genetic clones of one species are born to maternal surrogates of a different species.[18] The Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) describes this process as follows. When cloning mammals, the nucleus from a somatic cell – a body cell not specialized for reproduction – from an extinct species is taken. Subsequently, it is inserted into the egg cell of a suitable extant surrogate species, from which the nucleus is removed. The cell is induced to start to divide. After the cell has developed into an embryo, it is implanted into a surrogate host, again a close relative.[17] The organism born through this process will have a nuclear genome sequence identical to that of its extinct donor.[18]

In 2003, the first and only de-extinction through cloning took place. A calf was born, which was a clone of the last individual of the extinct bucardo species, a subspecies of the Iberian ibex. For the process, a skin sample was used that was taken a few years before from the last living individual. Different nuclei of the extinct species were inserted into enucleated eggs from domestic goats.[18] Whereas most of the embryos did not develop, a few did develop and one led to the birth of the bucardo.[19] The de-extinction was only partially successful: due to a lung deformity[20], it died just after birth.[18]

Current projects are seeking to clone the extinct gastric brooding frog, thylacine, and woolly mammoth.[17] Unlike back-breeding, cloning can create organisms that are identical to the donors of the extinct species, at least on the level of the nuclear genome. Cloning can therefore create individuals that resemble their extinct ancestors the most, compared to other de-extinction techniques.[18] Cloning does require intact living cells, which are not available for most extinct species.[18] Thus, interspecies cloning for de-extinction can most likely only work for species that went extinct recently, or for species from which cells have

[17] IUSCN SSC, 2016
[18] Shapiro, 2017
[19] Campbell & Whittle, 2017
[20] She had three instead of two lungs, and the third lung was more like a liver in its structure, hard and compact (Kornfeldt, 2018)

been collected, cultured and frozen before they died.[18] Places like the San Diego Frozen Zoo, which contains the cells, eggs, sperm, and even some embryos from about a thousand species, could be very useful for this purpose.[21] Currently, the oldest frozen specimen from which a healthy clone was made was a black-footed ferret, which was cloned from cells that had been frozen for thirty years.[22]

### *Genetic engineering*

For species that went extinct a long time ago, and from whom no intact cells have been preserved, genetic engineering could be an option.[23] The de-extinction of the woolly mammoth is an example of a project in which genetic engineering is used. Shapiro describes how decay processes that start after an organism dies, result in fragmentation and damage to the DNA. Due to advances in ancient DNA extraction and DNA sequencing, however, it has become increasingly feasible to reconstruct genomes of long extinct species. From tissue that has been preserved, for example in museum specimens or in the permafrost, short DNA fragments are mapped. By aligning the fragmented DNA of the extinct species with the complete genome of a close relative, the extinct genome can be reconstructed and important differences between the two species can be found. Genetic engineering, then, can be used to engineer genes of one species into the genome of the other. Changing every site where the sequence differs would lead to an enormous amount of changes, and it is not possible to predict the consequences of large-scale editing on genome stability. Thus, target phenotypes are identified, genes coding for the traits underlying these phenotypes are identified and engineered into the genome of the extant species.[24] This is done using CRISPR/Cas9 or other technologies.[25] From the engineered genome living cells have to be created in order to create living organisms. For mammals, this can be done using SCNT.[24] Unlike cloning, genetic engineering does not result in species with genomes identical to that of extinct species.[24]

## *1.4 Can we bring back extinct species?*

Before diving into the moral implications of de-extinction, it is important to discuss what de-extinction can and cannot achieve. What do we mean when we are talking about de-extinction? Is it possible to bring species back from extinction?

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[21] Kornfeldt, 2018
[22] U.S. Fish & Wildlife Service, 2021
[23] Sandler, 2020a
[24] Shapiro, 2017
[25] IUSC SSC, 2016

Several authors have emphasized that de-extinction cannot bring back authentic members of extinct species.[26] Beth Shapiro is a biologist specialized in ancient DNA, who works with Revive & Restore researching woolly mammoth and passenger pigeon.[27] She argues it might be feasible to resurrect extinct phenotypes, but never possible to create "an identical living copy of an extinct species."[28] In a similar vein, the IUCN SSC argues that neither back-breeding, cloning nor genetic engineering will be able to bring back extinct species "in their genetic, behavioural and physiological entirety."[29] Even cloning, Shaprio says, would not be able to create faithful replicas, despite being able to bring back species with the exact same DNA sequence as the extinct species.[30] The fact that organisms created through de-extinction will live in a different environment than the extinct species, can cause the genes – even if the sequence is the same – to be expressed differently.[30] Other factors can also result in differences. For example, cloned embryos will develop within the uterus of a surrogate species and will be raised by parents from a different species.[30] According to Meine, de-extinction can only bring back chimeric organisms and is therefore a literal impossibility. We can bring back the genome of a species, but not its "spatial and temporal context."[31] Both the IUCN SSC and Meine argue that it is therefore misleading to claim that we can overcome extinction.[32]

Campbell & Whittle disagree, and say that this argument is fallacious. It consists of two propositions: a) de-extinction can never create organisms that are identical to the extinct species, and b) a de-extinct organism can only be an authentic member of an extinct species if it is identical to the extinct species. Campbell & Whittle believe that the second proposition (b) of this argument is false. They say that even though characteristics of species change through time, this does not automatically meant that it are not that species anymore. Living populations of a species are never static.[33]

> To the contrary, mutation, selection, genetic drift and a changing environment are constantly driving shifts in a population's genetic, epigenetic, physiological and behavioural profiles, but we don't declare one species to have passed from the Earth and a new species to have been created in its place every time there is some such change.[34]

[26] Minteer, 2015; IUCN SSC, 2016; Meine, 2017; Greely, 2017 Shapiro, 2017
[27] Shapiro, 2015a
[28] Shapiro, 2017: 997
[29] IUCN SSC, 2016: 1
[30] Shapiro, 2017
[31] Meine, 2017: S13
[32] IUCN SSC, 2016; Meine, 2017
[33] Campbell & Whittle, 2017
[34] Campbell & Whittle, 2017: 70

They say that the fact that resurrected organisms will not be completely identical to members of extinct species, does not mean that they are not authentic members of the extinct species.[33]

Indeed, the second proposition implies a definition of a species that is quite essentialist, in the sense that a species is viewed as something which is unchanging. Since Darwin, however, biologists have come to realize that there are no characteristics inherent to a species, and all qualities are subject to change.[35] A strict essentialist view of species therefore seems difficult to defend in the post-Darwinian age.[35] On the other hand, genetic engineering and back-breeding are both likely to create organisms that not only a bit different from the extinct ancestors that they are supposed to resemble, but quite a lot. As will be describer later on, the woolly mammoth project aims to bring back something which resembles a cold-tolerant elephant more than it does a woolly mammoth. One does not need to hold a very essentialist definition of what a species is to argue that such an organism will not be woolly mammoth.

It seems, however, that to the IUCN SSC and Shapiro, to what extent de-extinct animals will be authentic members of extinct species might not be that important. As Shapiro argues,

> While the (...) new mammoths will not be genetically identical to extinct aurochs or extinct mammoths, there is no reason to expect that they would not graze, recycle and disperse nutrients, and as such help to maintain a diverse and healthy ecosystem, just as (...) mammoths once did.[36]

Indeed, she continues, exact replication of extinct species is not necessary to achieve the "conservation-oriented goals of de-extinction."[36] The goal of most de-extinction projects, she says, is to create functional proxies of species that once lived, "ecological proxies that are capable of filling the extinct species' ecological niche."[36] Similarly, the IUCN acknowledges that whereas de-extinction cannot create replicas of extinct species, it can "produce sufficient numbers of sufficiently genetically diverse individuals to form functional proxies of some extinct species."[37]

## *1.5 The value of nature*

Shapiro argues that using de-extinction in order to create ecological proxies of extinct species could help us reach our conservation goals.[38] This raises the questions: 'What are

[35] Ereshefsky, 2017
[36] Shapiro, 2017: 1001
[37] IUCN SSC, 2016: 1
[38] Shapiro, 2017

these conservation goals? What are the underlying values of these goals? And do all conservationists share these?'

## *Biodiversity*

That species and biodiversity are valuable is widely acknowledged by conservationists. Indeed, a major goal of conservation biology is the promotion of biodiversity, which is often refers to the diversity of ecosystems, species and genes and phenotypic traits within these species.[39] Because biodiversity is valuable, preventing extinctions from happening is an important goal for conservationists. According to Meine, the fact that we feel responsible for this follows from the understanding that our species is the cause of most of recent extinctions, due to overexploitation, habitat destruction and introduced species, enhanced by human-induced climate change.[40] "These facts and Darwin's idea of irreversibility of extinctions constitute the ethical foundation for conservation biology: the designation of human responsibilities with respect to biodiversity."[41]

Overall, biodiverse ecological systems have proven to be well-functioning systems, in the sense that they provide us, and other species, with goods and services. When species disappear from their ecosystem, this can reduce the stability of the system.[42] Keystone species such as the aurochs and the woolly mammoth have a disproportionately large effect on what an ecosystem looks like, and are therefore often seen as extremely valuable from this perspective. In this sense, biodiversity is instrumental to the end of ecosystem stability and resilience. Biodiversity is also recognized, however, as being valuable in itself. We like having species, not because they are instrumental to us but because they are beautiful, fascinating, and because we have a preference for a thriving wilderness with a lot of biodiversity. Some go even further in arguing that species do not merely have subjective value, but objective value. This means that they have value even without humans being present to value them.[43]

## *Naturalness*

Importantly, however, biodiversity is not the sole aim of conservation. Instead, it is often at tension with other important values. As Angermeier points out, we could increase biodiversity through genetic engineering and introducing species to other ecosystems, manufacturing a world more diverse than the one that came into being through

[39] Campbell & Whittle, 2017
[40] Meine, 2017
[41] Oksanen & Siipi, 2014: 2
[42] IUCN SSC, 2016
[43] Sandler, 2012

evolutionary processes. However, he argues that most conservation biologists would not see this as an increase in value, because they prefer native diversity over artificial diversity.[44] Underlying this preference is the value of naturalness. Like wildness, the meaning of naturalness is closely related to processes or things that lack human intervention.[45] However, when applied to species and ecosystems, the value of naturalness is often considered to be high when species and ecosystems come close to historical benchmarks.[45] The implication of this is that an ecosystem can be considered natural even after extreme human intervention, as long as it contains the same species composition as it did at the time of the benchmark.[45]

Some conservationists are less concerned with naturalness. Emma Marris, for example, questions the assumption that native ecosystems are better than changed ecosystems.[46] She argues that we should expand our definition of nature.[46] But she goes a step further. "[O]nce we do change [our understanding of nature], a heretofore unthinkable, exciting, and energizing thought occurs: we can make *more* nature. We can make things on Earth better, not just less bad."[47] It might sometimes be a good idea to intentionally design new ecosystems, using no historic baseline at all, she says.[46] Those restoring nature often assume that historical systems are not only morally better, but have more biodiversity and better ecosystem services. [46] However, this does not have to be the case, and ecosystems designed specifically for such purposes might be better at doing that.[46] However, such ecosystems would not do very well with regards to naturalness.

## *Wildness*

Despite the earlier discussed problems with the concept of wilderness, wildness is still important for many conservationists.[48] Wildness is often used to describe those things and processes that are spontaneous.[49] Whereas wilderness referred to those areas untrammelled by humans, wildness can refer to wild processes. While wilderness disappeared as soon as humans came in, wild processes can still exist in ecosystems and organisms that are influenced by humans. Clare Palmer differentiates between two types of wildness: constitutive wildness and self-willed wildness. Constitutive wildness lies at the other end of the spectrum from domestication, and decreases as a result of selective breeding, adaptation to live alongside humans, and adaptation for human use or purpose. Self-willed wildness, on the other hand, refers to those things governed by their own

[44] Angermeier,1994
[45] Ridder, 2007
[46] Marris, 2013
[47] Marris, 2013: 56
[48] Preston, 2018
[49] Ridder, 2007

processes, as opposed to human management. Organisms that are self-willed wild, are free from human-caused constraints and are free to express their species-specific behaviour, purposes and desires. Both these types of wildness are valued, and human impact does not always decrease both these types of wildness similarly. [50]

Rewilding is a practise in which wildness is really important. In the Netherlands, the Oostvaardersplassen have been created, one of the first rewilded areas. Herbivores have been introduced to restore ecological processes that are believed to have been key in European landscapes of the past.[51] Even though the area was created by human hands, increasingly, wild processes are taking over. Creator Frans Vera says that how it came to being is not important, but rather how well it is able to maintain itself afterwards through human-independent processes. "Forget past versus present – it is really natural versus cultivated," he says.[52] Although inspired by historical baselines, the most important thing in rewilding seems to be the establishment of wild processes, rather than necessarily a certain species composition (as is the case with naturalness).

### *Ecosystem services*

Whereas Soulé argued in 1985 that nature conservation was mainly about protecting biodiversity for its inherent value,[53] Kareiva and Marvier revisit his article and add the importance of protecting nature because it provides us with products and services.[54] Nature can purify our water, sequester our carbon, protect us from natural disasters and provide us with food and medicine. According to Kareiva and Marvier, that these services have become a primary motivation for nature conservation.[54]

When we value nature for its ecosystem services we value it in a very instrumental way: it is valuable not in itself but because it serves an end that we find valuable. When we recognize species only for their instrumental value, this implies that it would not matter to us if they were replaced with something else that is instrumental towards the same end.[55] For example, if we value bees merely because they pollinate our crops, replacing the bees with an artificial means of pollination would not be problematic, because their value lies only in their function as pollinators. Many conservationists, however, would think that an artificial means of pollination would be of less value than having bees, even when artificial pollination would be at least as effective. This is because they value bees for more than just their instrumental value, but because they are

[50] Palmer, 2021
[51] Marris, 2013; Goderie et al., 2013
[52] Frans Vera in Marris, 2013
[53] Soulé, 1985
[54] Kareiva & Marvier, 2012
[55] Sandler, 2012

intrinsically valuable to them. It is possible to value nature for the services it provides, while at the same time recognizing that it is intrinsically valuable too; however, it is important to note that there can be a tension between the two.

### *Autonomy*

Stewart Brand is one of the more famous ecomodernists, like Emma Marris. Kornfeldt describes how Steward Brand envisages a world in which humans manage nature. "It's a world in which people assume responsibility, but also exercise power: releasing new animals, building new versions of ecosystems, editing animals' genes to enable them to thrive better."[56] Interventions such as those proposed by Marris and Brand, while possibly enabling nature to provide more ecosystem services and be more biodiverse, would decrease another value that many conservationists hold dear: the autonomy of nature. This decrease in autonomy would be a result of increasing human domination. We can be said to dominate nature when we see nonhuman nature as objects for us to use, rather than as subjects with their own goals.[57]

A long-standing value commitment associated with conservation is that human-independent ecological and evolutionary processes, and the products of them, have value in themselves or for what they are. The basis of this value can be their spontaneity, connection to deep time, complexity, and otherness, amongst others.[58] Those that value nature mainly for these reasons usually believe that nature conservation should be about "mitigating anthropogenic loss, limiting the rate of anthropogenic change, and maintaining human-independent evolutionary and ecological processes."[59] One of the proponents of such a view is Robert Elliot, who said that we value the forest and the river because their existence is independent of us, and their value is based on this fact and thus dependent on its continuity with the past. Intervention by humans would always decrease this value.[60] In this important sense, the autonomy of nature is different from wildness. Wildness can be apparent in processes, even in human-designed areas. However, nature is autonomous only when humans refrain from controlling and designing it.

[56] Kornfeldt, 2018
[57] Bovenkerk, 2020
[58] Soulé, 1985; Sandler, 2012
[59] Sandler, 2020a: 382
[60] Elliot, 1982

## *1.6 Overview thesis*

"From a philosopher's perspective, de-extinction is a delightfully controversial subject."[61] While it might help us achieve some of our conservation goals, de-extinction invites a more interventionist approach towards nature.[62] Whereas ecomodernists generally embrace such approaches, not all conservationists might be as enthusiastic. Some conservationists are faced with a moral dilemma.

For those who mainly care about the instrumental value of species or about increasing biodiversity, de-extinction might prove to be a very useful conservation strategy if it appears to be able to help re-establish ecosystem stability and functioning, and increase biodiversity through the creation of ecological proxies.[63] For those conservationists that are concerned with protecting nature from too much human influence and control, de-extinction might prove to present more of a dilemma. On the one hand, stable and well-functioning ecosystems could be important in creating resilient ecosystems, mitigating further species extinctions in the face of ecological and climatic change. On the other hand, de-extinction might compromise those other values that conservationists find important, such as values of wildness and autonomy.

This thesis looks at de-extinction from an ethical perspective. The objective is to examine the moral implications of de-extinction and explore to what extent these apply to different de-extinction projects. Importantly, the goal is not to determine whether or not de-extinction is morally acceptable in general, but for conservationists specifically. As Campbell & Whittle argue, the difference lies in the fact that overall, conservationists are devoted to certain beliefs, such as the belief that biodiversity is worth saving and protecting.[64] "Conservationist's acceptance of these doctrines imposes logical constraints on what they can say about the ethics of de-extinction."[65] If one believes that promoting biodiversity is an ethical undertaking and de-extinction can seriously contribute to this goal, disregarding de-extinction becomes more difficult. At the same time, this delineates the scope of this thesis. Some de-extinction projects might be valuable from the perspective of medicine, for example. Here, the focus will only be on those values and concerns related to nature conservation, and others will not be considered to a significant extent.

The de-extinction projects of the aurochs and woolly mammoth will serve as case studies throughout the thesis. These cases will be examined in chapter two. The cases

[61] Campbell & Whittle, 2017: vii
[62] Preston, 2017
[63] IUCN SSC, 2016; Shapiro, 2017
[64] Campbell & Whittle, 2017
[65] Campbell & Whittle, 2017: 88

differ from each other with regards to important aspects, such as the technique that is used, as well as the date of extinction, which makes them interesting to compare. Furthermore, both are prominent projects that have been underway for some years. After the cases have been examined, chapter three will discuss the most important moral concerns with de-extinction. But, as will become clear throughout the thesis, de-extinction projects can differ from each other in many ways. Therefore, chapter four will examine to what extent these concerns apply in the two case studies. Because the aim of the thesis is to compare the de-extinction cases of the aurochs and woolly mammoth, the focus will be mainly on back-breeding and genetic engineering (rather than cloning). The final chapter will be dedicated to answering the question "Can de-extinction be morally justified as a conservation strategy, and if it can, in which cases?", the research question of this thesis. The thesis will end with a conclusion.

# 2 De-extinction candidates

In this chapter, two de-extinction projects will be discussed: the Taurus foundation's project aiming to resurrect the aurochs through back-breeding, and the project from organization Revive & Restore, which aims to bring back the woolly mammoth through genetic engineering. These cases will serve as examples throughout the thesis.

## *2.1 The aurochs*

Our lives would be very different if it weren't for the aurochs, the ancestor of all domestic cattle in the whole world. Goderie et al. describe how the aurochs were the largest land mammal for thousands of years in Europe, where they were important shapers of the landscape. Together with other herbivores they created a diverse grassland and parkland ecosystem during the early Holocene. Around 9,000 years ago, humans started to hunt wildlife to such an extent that their populations were being depleted, and proof has been found that herds of aurochs were targeted on a large scale. Two thousand years later, humans transitioned to farmers and herdsmen, which meant that they began with domesticating animal and plant species. The aurochs were seen as competitors of their domesticated counterparts and were made to retreat to less hospitable land. As humans populations kept on growing, aurochs populations declined further until the last aurochs died in 1627 AD.[66]

For millions of years, European landscapes have developed with wild herbivores, following with 10,000 years of domesticated herbivores, both of which kept the landscape open and the forests from taking over. Currently, however, one million hectares of farmland are abandoned per year, which without herbivores present, will be quickly overgrown with shrubs and trees. This is why Goderie et al., representing the Taurus foundation, ARK Nature & Rewilding Europe, argue that we need large numbers of cattle populations to prevent the decline or even the disappearance of all the species dependent on these ecosystems. In order for them to be self-sufficient in rewilded landscapes with predators, they need to be more like the aurochs, and less like our domesticated cows.[66]

[66] Goderie et al., 2013

Heck cattle, as discussed in the introduction, are generally not considered to be successfully back-bred aurochs, looking little like the aurochs and sharing even less of its genome.[67] More advanced back-breeding projects are currently being carried out to bring back the ancestor of our modern day cattle.[68] One of them is the Tauros programme, which was initiated in 2008 by the Dutch Taurus Foundation.[68] Advancements in genomic research make it easier for the Taurus foundation to approximate the aurochs than it had been for the Heck brothers. The now fully sequenced aurochs genome is being compared to the genome of extant cattle breeds, which makes choosing the right animals to breed a lot easier.[68] According to Goderie et al. the Taurus Foundation wants to develop free-living populations of self-sufficient cattle, able to fill the ecological niche that the aurochs used to fulfil in Europe's historical landscapes. The goal is to create a species that looks like, and is genetically and behaviourally as similar as possible to the extinct aurochs, and will be called the Tauros. The Tauros programme started with hands-on human action, including artificial insemination, embryo transplantation and active natural breeding. This would gradually make way for a hands off approach, in which natural selection is the only breeding strategy. During this phase, the Tauros species would become a truly wild animal.[69]

## *2.2 The woolly mammoth*

The woolly mammoth used to roam the subarctic grassland steppe, which stretched the northern parts of the planet during the last glacial period, from Canada to Spain. This was a cold but biodiverse and productive habitat, roamed by large herds of animals.[68] In Eurasia and North America the woolly mammoth went extinct between 8,000 and 10,000 years ago, while isolated populations survived on islands until 3,700 years ago.[70]

Why the woolly mammoth went extinct is not known for certain, and subject to debate. Beth Shapiro believes it is a combination of three different factors. First, a shift from a glacial to an interglacial interval occurred about 10,000 years ago, which typically led cold-adapted species to become less widespread, living in isolated patches. This was a normal pattern. However, this time, human hunting likely caused the populations of woolly mammoths to become isolated even further from each other and the resourced they needed.[70] Furthermore, rapid warming caused a decline in the steppe vegetation, which was reinforced by the declining density of animal populations needed to keep

[67] van Vuure, 2005
[68] Campbell & Whittle, 2017
[69] Goderie et al., 2013
[70] Shapiro, 2015a

mosses, shrubs and trees from taking over.[71] The decline of the steppe might have been the third contributor to the mammoth's extinction.[70]

Currently, in north-eastern Siberia, ecologist Sergey Zimov has created 'Pleistocene Park,' large nature reserve in which herds of large herbivores have been introduced. He is testing his hypothesis that restoring the steppe grassland can contribute to climate change mitigation by slowing down the thawing of the permafrost, which contains more carbon than all rainforests combined. According to Zimov, this will happen in two ways. First, grasslands reflect more sunlight back into space than forests, so restoring the grassland steppe could slow down warming of the atmosphere.[72] Secondly, trampling by large herds of grazers will break up the layer of snow. Being a powerful insulator, snow prevents the cold Siberian air to really penetrate the permafrost during winter, so trampling will lead to deeper freezing of the permafrost. So far, the results of Zimov's experiment are positive, and grasses have taken over the area. The aim is to add more animals to the park and expand the area of enclosed land.[73]

Inspired by Zimov's experiment George Church, a geneticist at Harvard University, started working on a project to resurrect the woolly mammoth through genetic engineering.[74] He started doing this in 2014, working together with Revive & Restore, a non-profit organisation created by Stewart Brand and Rhyan Phelan[75]. Recovered DNA fragments of the woolly mammoth have been used to sequence the woolly mammoth genome, which was finished in 2017.[74] Differences between the genome of the woolly mammoth and its closest relative, the Asian elephant, have been identified. The differences are not many: "the Asian elephant is already 99.96% of the way to being a woolly mammoth, genetically speaking."[76] The goal is to edit the genome of the Asian elephant so that it will contain the parts of mammoth DNA that code for important differences, like those that contributed to the mammoth's cold-tolerance. So, rather than a woolly mammoth, a sort of 'mammophant' is created, an elephant that can survive the Siberian cold and can therefore serve as an ecological proxy for the mammoth.[76] Since using endangered Asian elephants as surrogates is hard to justify, the plan is to grow the created embryo in an artificial womb[77], a technology which is still being developed.[74]

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[71] Shapiro, 2015a; Pleistocene Park, n.d.

[72] Whereas forests are commonly believed to be great weapons in mitigating climate change by taking up carbon, some scientists argue that the effects are more complex. By absorbing sunlight, trees can also have a warming effect on the planet. This effect mostly occurs at higher latitudes– the location of the Pleistocene park – where slow growing and dark coniferous trees cover light-coloured ground or snow that would otherwise reflect sunlight (Popkin, 2019)

[73] Zimov, 2005

[74] Campbell & Whittle, 2017

[75] Revive & Restore, n.d., a

[76] Campbell & Whittle, 2017: 40

[77] Interestingly, in Jurassic Park, dwarf elephants were also being grown in an artificial womb (Crichton, 1990)

Currently, genes that code for unique mammoth traits have been identified, such as mammoth hemoglobin, extra hair growth and fat production. CRISPR/Cas9 techniques have been used to engineer these into living elephant cell cultures. For a few genes, this has been achieved.[78]

The organization Revive & Restore gives multiple justifications for the de-extinction of the mammoth. First of all, they argue that the woolly mammoth can play an important role in keeping trees from growing in the arctic grasslands, and dispersing large amounts of nutrients via their dung. This way, mammoths can help keeping the steppe grasslands intact, which according to Zimov's theory could potentially help mitigating climate change. In addition, discovering more about ancient DNA can unravel secrets that could benefit modern biology as well as medicine. And lastly, technologies that will be developed for mammoth de-extinction could increase our ability to conserve elephant and other species.[79]

## *2.3 Why the aurochs and mammoth?*

The de-extinction projects of the aurochs and mammoth are different from each other with regards to important aspects. The auroch went extinct around 400 years ago, while the last mammoth died approximately 4,000 years ago. While George Church's team is using the newest genetic engineering technologies, the Tauros foundation is using selective breeding techniques we have been using for thousands of years. What these projects have in common, however, is that both aim to bring back organisms to serve as an ecological proxy of an extinct species to restore certain ecosystem processes and functions.

These justifications are not that convincing, however. When the goal is merely to restore ecological functioning, this raises the question of whether it is really necessary to bring back extinct species to carry out this task. Indeed, in many cases of de-extinction using currently existing species is probably easier and less costly.[80] In the case of the aurochs, it is unclear why the Heck cattle would not suffice as an ecological replacement. Currently, there are around 3,000 Heck cattle worldwide who are doing fine in the wild.[81] Goderie et al. do argue that the heck cattle are not back-bred very well. "They are small, haven't got the slender and elegant proportions of the aurochs and because of the wide variety of breeds used, the breed is not at all very 'stable'."[82] In addition, their Nazi origins

[78] Revive & Restore, n.d., b
[79] Revive & Restore, n.d., a
[80] Sandler, 2017; Campbell & Whittle, 2017
[81] Kornfeldt, 2018
[82] Goderie et al., 2013: 134

are often held against them.[81] But, Goderie et al. do admit that Heck cattle are a self-sufficient breed which for decades have managed to survive under difficult and relatively wild conditions.[83] If the goal of the Taurus project is to have self-sufficient breeds of cattle to keep the landscape half-open – as they claim it is – it seems that the Heck cattle might suffice. Of course, Heck cattle are also the product of de-extinction, but since they are already there, using Heck cattle would escape the concerns that would apply to carrying out yet another back-breeding project. And, maybe we don't even need Heck cattle. As Goderie et al. say themselves,

> in some corners of Europe, certain cattle breeds changed very little over time. Especially so in a few geographically isolated patches in Italy, Spain and the Balkans, where cattle breeds have survived since very early times, living a pretty wild and hard life, seemingly without very heavy interference by man. Some of these original breeds live where there are wolves around and still know how to defend themselves."[84]

Similarly, in the case of the mammoth it appears that using extant large herbivores, like the ones that have been introduced into the Pleistocene Park already, are likely to be sufficient as ecological engineers. Nikita Zimov, son of Sergey Zimov and the current director of Pleistocene Park, says that he would be happy to take a cold adapted elephant in, because it would probably make it easier to transform the vegetation.[85] However, he says that their goals can be achieved without the mammoths as well.[85] "[De-extinctionists] need us to justify their work. (...) Our work started before people even started thinking about doing any mammoth cloning research."[85] On the other hand, it is not difficult to imagine that it would be really valuable to have large herbivores ripping out trees in the landscape, rather than the old army tank that is currently being used to fulfil this role.[86] This ecological function is typical for megaherbivores, most of which have disappeared from ecosystems in the northern hemisphere.

For both projects, using de-extinction does not seem that necessary to achieve the formulated goals. Other self-sufficient cattle could possible keep rewilded landscapes half-open, and the Siberian steppe ecosystem is already being restored without the mammoth present. It might be that there is an underlying motivation behind these de-extinction projects. Maybe de-extinction offer us hope of undoing our faults[87] or we try to bring these species back because we would find it very cool to see these animals again.[88]

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[83] Goderie et al., 2013
[84] Goderie et al., 2013: 120
[85] Animal People Inc, 2017
[86] Keulartz, 2019
[87] Herridge, 2014
[88] Sherkow & Greely, 2013

It cannot be a coincidence that de-extinction projects focus on species that are charismatic, beloved and missed dearly – although according to the IUCN SSC, this is no different from the bias already apparent in conservation biology.[89] The mammoth is an iconic animal, and the potential of its comeback sparks wonder even in those opposed to resurrecting it. As paleobiologists Teri Herridge says, "for all my protests, I'd pay to see one if it was there, wouldn't you?".[87] De-extinction projects furthermore seem to be very nostalgic. Both projects seem to romanticise a certain time in which nature was wilder and more biodiverse than it is today. According to Phil Seddon, romanticising natural phenomena of the past is risky. "Projects that aim to recreate a vanished ecosystem in one way or another are often based on the assumption that there was once a time when everything was wonderful, in perfect balance. There's a sense that if only we could recreate that state of affairs, everything would be just fine. But all environments are subjects to constant change; nature has never stood still."[90]

These are just speculations, and they do not have to be true for all conservationists. However, the case for these de-extinction projects so far does not seem that strong from an ecological perspective. If the projects are indeed motivated by other things like nostalgia and coolness, this is a lot less convincing from a conservationist's perspective than the justifications given by the organisations.

[89] IUCN SSC, 2016
[90] Phil Seddon in Kornfeldt, 2018

# 3 Ethical concerns

In order to determine whether pursuing de-extinction can be justified, the following chapters will be concerned with the moral implications of using de-extinction for conservation purposes. In each section, a specific argument will be examined.

## *3.1 A technological fix*

One objection that has been made against de-extinction is that it is merely a technological fix to the problem of species extinctions.[91] The term "technical fix" was coined in 1960s by Alvin Weinberg to describe the use of technological solutions to solve complicated societal problems that should instead be solved by social and political change.[92] The accusation of something being a technological fix, or technofix, is often used to accuse those technological solutions that do not address the underlying deeper causes of a problem, but merely treat the effects.

Several authors have accused de-extinction of being a technofix.[93] According to Jennings, de-extinction is merely a technological solution created for the specific task of returning a species, without providing the assurance that the systemic problem behind the extinctions is resolved.[94] And as Sandler says, de-extinction does nothing to address the fact that there is no place for the extinct species anymore.[95] "The conservation problem in the Anthropocene is not just that there are no passenger pigeons, thylacines, Yangtze River dolphins, or Monteverde golden toads. It is that there is no longer a suitable place for them within ecological systems."[96] Stuart Pimm, biologist and expert in species' extinctions explains this further. According to him, conservation is not just about bringing back a species. It is about the ecosystems in which they live, the human communities with whom they interact, and finding sustainable alternatives for the practises that threaten

[91] Jennings, 2017; Sandler, 2017
[92] Preston. 2018
[93] Jennings, 2017; Sandler, 2017; Meine, 2017
[94] Jennings, 2017
[95] Sandler, 2017
[96] Sandler, 2017: S46

them. At most, de-extinction can be a minuscule part of solving the crisis of species extinctions.[97]

> [De-extinction] is a fantasy that real scientists—those wearing white lab coats—are using fancy machines with knobs and digital readouts to save the planet from humanity's excesses. In this fantasy, there is none of the messy interaction with people, politics, and economics that characterizes [the world of conservation]. There is nothing involving the real-world realities of habitat destruction, of the inherent conflict between growing human populations and wildlife survival.[97]

One of the reasons why de-extinction is prone to the concern of being a technological fix, is because it is reductionistic. In his article *The community of being,* Meine describes how in the 1930s, a paradigm shift in conservation biology occurred. Whereas first, the fate of species was seen as isolated in space and time, now the focus became about the health of biotic communities and ecosystems. In addition, conservation biologists increasingly came to realize that species are embedded in a social and cultural dimension as well. Meine is amazed that, many decades after this paradigm shift, de-extinction seems to regard species again in the old-fashioned manner, detached from its ecological relations, as well as evolutionary and human context. Meine argues that this can have serious implications. Seeing extinctions as something that is relational, and implicated in the human social context, means that they require ethical consideration. When species are seen in a more reductionist manner, with the emphasis on the genome, this ethical consideration becomes less pronounced. When we believe that saving the genome of a species is enough to bring back the species and all what is valuable about it, we might feel less like we need to change ourselves.[98]

Meine explains how experience from species reintroductions has taught conservationists that whether or not reintroductions are successful, always depends on factors related to the behaviour, population dynamics and ecological relationships of the species, as well as the human social contexts in which they are reintroduced. The reintroduction of the whooping crane provides a good example. After seventy years of hard work, its extinction was just prevented. After it was reintroduced into the wild, however, at least one in five of the birds were illegally shot again. This shows the necessity of encouraging sustainable relationships between humans and the surrounding natural world remains, and Meine suggests that this might be even more difficult than just bringing back the genome of extinct species. What anthropogenic threats to biological diversity warrants is ethical innovation, not just technical innovation, even though the former is more difficult to achieve.[98]

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[97] Pimm, 2013
[98] Meine, 2017

Overall, de-extinction indeed seems like a technological fix to the crisis of species extinctions. As nature conservationists, we try to prevent those extinctions that are the result of our behaviour. This calls for introspection and changing ourselves, rather than changing our environment. Believing we have a technological fix to the problem of anthropogenically caused mass extinctions, might undermine our commitment to change our own behaviour.[99] On the other hand, societal change is a slow process, and the rate of extinctions is very high. The case could be made that de-extinction could be part of a larger conservation plan that also addresses the systemic causes of species decline. Sandler argues that, when carried out like this, de-extinction does not need to be a technological fix.[100]

The projects of the woolly mammoths and aurochs are not carried out to make up for the extinctions of the animals themselves. Rather, they are justified because they might increase ecosystem resilience, mitigate climate change and save other species from going extinct. In this sense, these approaches are more holistic already than the technological fix critique suggests, not merely trying to undo the extinction itself but taking a forward looking ecosystem approach. Still, they still do not seem to address the deeper causes of extinction related to human behaviour and are therefore still prone to the concern of being technological fixes.

De-extinction is a solution which is very much in line with ecomodernist thinking. Generally, ecomodernists are quite positive and optimistic towards the use of technology to solve the environmental crisis. Although they acknowledge that technological power has been used to the detriment of the environment before, they believe that further, more conscious technological innovation could be useful in making ecosystems more resilient and less susceptible to human-induced change.[101] They believe that a nature that is more resilient will allow the human species to continue with modernization, while saving nature at the same time. In order to achieve this we should take our responsibility and start managing nature.[101] De-extinction seems to be in line with such thinking and it is therefore no surprise that Stewart Brand, one of the two founders of Revive & Restore, is also one of the authors of the Ecomodernist Manifesto. As a result, ecomodernists might not be as concerned with the use of technological fixes to the crisis of species extinctions. Those who think we need to take a more humble approach and change our behaviour instead, will likely see de-extinction as a technological fix in the sense that it is reductionist, and as long as it is not accompanied by ethical innovation as well, it might not help us that much further in the long run.

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[99] See the Moral hazard section
[100] Sandler, 2014
[101] Jennings, 2017

## *3.2 Moral hazard*

Some critics argue that de-extinction not only does not address the causes of extinction, but even has the potential of reinforcing them. The IUCN SSC, Greely and Jennings are worried about this effect, which they refer to as the danger of creating a moral hazard.[102] What this means is that the realization that extinction is not final could decrease public support for the preservation of species currently at risk of extinction, hereby undermining conservation efforts.[103] Stuart Pimm even warns that it could enable the extinctions of species to be excused on the basis that the harm can be undone at a later date.[104]

Ecologist and conservationist Josh Donlan, however, proposes that de-extinction is more likely to have opposite effect on support for conservation. The moral hazard argument assumes that the public cares for species protection in the first place. Donlan thinks that most of the public is indifferent to such issues and that we therefore need strategies that can increase public support.[105] He believes that de-extinction might be such a strategy.[106] Jennifer Welchman delves into this possibility a bit further. She argues that there is no evidence that de-extinction projects will be morally hazardous, but that there is a large amount of evidence that shows that feeling powerless in the face of environmental problems can result in detachment from these issues. De-extincting and reintroducing a species into its former habitat could inspire the community in which it is introduced to develop new virtues and care more for its environment.[107]

Shapiro claims that the moral hazard argument shows a horrible view of people.[108] "It assumes that at the slightest (and I mean *slightest*) hint of a quick fix, no matter how not-so-quick and not-quite-a-fix it is, people will give up trying to preserve endangered species."[109] She finds it hard to imagine that people who care about biodiversity conservation would suddenly stop doing so. However, she does see how those who do not care about biodiversity conservation, or those who could gain benefit from species being removed from protection, could use de-extinction to further their agenda.[108]

It might indeed be true that we need more positive stories in order to get inspired to protect our natural environment, as Donlan and Welchman have argued. This is quite a strong argument in favour of a change in narrative. However, whether de-extinction is the

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[102] IUCN SSC, 2016; Greely, 2017; Jennings, 2017
[103] IUCN SSC, 2016: 201
[104] Pimm, 2013
[105] He bases this on Kareiva & Marvier (2012), who cite a poll done in the US (https://news.gallup.com/poll/1615/environment.aspx) which shows that over the years less people prioritize the environment over the economy
[106] Donlan, 2014
[107] Welchman, 2021
[108] Shapiro, 2015a
[109] Shapiro, 2015a: ch. 11, "if de-extinction is possible"

only way to go about this is unclear. There might also be other ways to change the narrative, such as by celebrating success stories in species preservation. I find it hard to believe that people will start caring more about nature conservation when a genetically engineered cold-tolerant elephant is introduced into Siberia. Sure, seeing mammoth-like creatures roaming Siberia again, might give us a feeling of wonder and make us marvel, but it seems just as likely that it will cause us to overestimate our abilities. Important therefore would be a clear communication of what de-extinction really can really achieve, what it cannot, and what the risks are. As Sandler argues, it should be made clear that species cannot be brought back without loss.[110] The more clear this is, the less likely that de-extinction can lead to a moral hazard.

## *3.3 Artefact creation*

Another concern that could be voiced to oppose de-extinction is that as a conservation strategy, it merely creates artefacts. In his essay *The Big Lie*, Eric Katz voiced his concern about restoration of ecosystems. He argues that we are arrogant when we believe that we can restore nature, when we can only create artefacts, which are things created for human purposes. When we manipulate nature we impose our purposes on nature also, thus turning it into an artefact. Not all restorations are equally problematic, he argues, but they all involve domination of nature by denying its freedom and autonomy, which ultimately destroys its value.[111] The same goes, according to Katz, for resurrected species.

> These things are ontologically different from the original; they have a different being or essence than the original. The new species is not really a natural species. It may look and act like a species, but it's really a human creation.[112]

His argument has since been critiqued because it implies a distinction between humans and nature. As Welchman says, the argument that de-extinct animals are artefacts relies on questionable assumptions about what is natural and what is artificial.[113] "If de-extinct Heath Hens are technological artefacts, what then are the thousands of children born every year from in vitro fertilized donor eggs? Pseudo-human franken-children who should be kept apart from their more authentic, naturally-conceived counterparts?"[114]

It is true that things do not immediately become unnatural as a result of human influence, and even when something can be considered unnatural, this does not mean it is ethically wrong. Still, an uneasy feeling lingers. It helps to look at the more nuanced view

[110] Sandler, 2019
[111] Katz, 1992
[112] Katz in O'Connor, 2015: 244
[113] Welchman, 2021
[114] Welchman, 2021: 517

put forward by Cohen. He proposes that there is a spectrum, with humans designing organisms from scratch on the one hand, and reintroducing species after a local extinction on the other hand. Whereas the former would imply that one is really designing nature, the latter would be more like designing a nature-based solution. De-extinction lies somewhere in the middle: de-extinct organisms are not exact replicas of extinct species, but they are not product of human imagination either. In addition, Cohen argues that the goal of de-extinction is also important in determining to what extent it creates artefacts. Carrying out de-extinction for human purposes would increase the extent to which the resulting organisms are artefacts. However, when it is carried out to serve biocentric goals, the resulting organisms are not tools for human purposes and therefore not artefacts.[115]

The projects of the woolly mammoth and aurochs seem to avoid the concern of artefact creation at least partially, since their goal is to restore ecological functioning and save other species from extinction. However, undertaking this projects still implies that we know what is best for nature and that we should take on the role enforcing this. Furthermore, there is a strong ecomodernist sentiment present in these projects, which warrants caution. Making ecosystems more resilient in such a way so that we can carry on with modernization, would still mean that the purpose is human-oriented.

## *3.4 Animal rights and welfare*

Central to de-extinction are the animals involved, and it is therefore not surprising that animal rights and welfare concerns have often been raised to oppose de-extinction. Going beyond welfare, animal rights advocates might oppose de-extinction as they oppose zoos—on the grounds that they exploit animals for human purposes.[116] In contrast with utilitarian theories, deontological ethical theories like animal rights do not judge an action based on its consequences, but on the action itself. One of the most influential animal rights theorists is Tom Regan. He argues that like humans, nonhuman animals have inherent value, because there is no rational basis on which we could differentiate between the two. Instead of focusing on the differences between humans and nonhuman animals, he argues that like us, animals are experiencing subjects of a life, and therefore have interests. Treating animals as objects, as if their value can be reduced to their usefulness to others, denies these interests.[117]

[115] Cohen, 2014
[116] Sherkow & Greely, 2013
[117] Regan, 2007

The animal rights perspective is often contrasted with the perspective of animal welfare, which judges actions based on their consequences and is mainly concerned with avoiding suffering and pain. Within such a utilitarian view, one might say that harming a few animals could be justified on the basis that it can benefit us, or members of other species.[117] Stewart Brand, for example, argues that initial suffering of animals could be justified on the basis that it will benefit later lives.[118] Indeed, the projects of the woolly mammoth and the aurochs could be justified on the basis that these can benefit other individuals in the future. Within a rights view as proposed by Regan this would not be justified, because there are just certain lines that should not be crossed when concerning a being with interests; individuals should never be sacrificed for the greater good or used as merely a means to other individuals' ends. Most people would agree that we should not use humans in such a way, and according to Regan's view, we should not treat animals in such a way either. This makes one wonder whether Brand would take such a consequentialist view as well when we would be talking about humans instead of nonhumans animals. Maybe he thinks that animals do not have the same rights as us, and it would be interesting to know what he would base this on.

From the perspective of animal rights, animal breeding and captivity is inherently problematic, because animals are used as means, rather than ends.[119] From the perspective of animal welfare, de-extinction is only problematic if it causes suffering in animals. Many authors agree that animal welfare should be addressed before carrying out de-extinction projects, so suffering is minimised,[120] although some of them also argue that these welfare concerns do not significantly differentiate from current conservation practises involving animals.[121] However, the fact that welfare issues already occur in existing conservation practises should not excuse welfare issues in de-extinction.

## *3.5 Inherently risky*

In the *Jurassic Park* novel, the genetically engineered dinosaurs start to reproduce, escape the island and kill the scientists that created them. The novel is critical of humans that arrogantly believe they can 'play God."[122] It is a concern with hubris, an ancient Greek concept referring to extreme pride or overconfidence, and as a result forgetting that you are a human with limited abilities.[123] In Greek classical stories, hubris was a character flaw

[118] Kasperbauer, 2017
[119] Gamborg, 2014
[120] Sandler, 2014; Rohwer & Marris, 2018; Friese & Marris, 2014; Novak, 2018; Shapiro, 2015a
[121] Sandler, 2014; Rohwer & Marris, 2018
[122] Miracky, 2004
[123] Woodruff, 2014

leading heroes to overstep the boundaries of human limitations, provoking the wrath of the gods.[124] It is the opposite of the virtue called reverence, which is the capacity to feel awe, respect and shame when this is appropriatate.[123] Concerns about hubris arise often in the context of intentional intervention in nature, and the worry is that researchers overestimate their ability to predict and control the consequences of their technologies. [125] Such unease is based on the belief that nature cannot be controlled. [126]

Risks, such as the risk that a resurrected species will turn out to be ecologically invasive, are to some extent always involved in conservation practises like reintroduction and translocation.[127] However, it is likely that de-extinction – and especially de-extinction of long lost species – has a higher chance of unpredicted outcomes, as it involves species that we might have never seen alive and lack enough knowledge about.[128] Sandler and Campbell & Whittle argue that hubris does not need to always apply to de-extinction projects, and that it is merely an extrinsic concern. Projects can be undertaken in ecologically sensitive ways, taking ecological risks into account.[129] Preston, on the other hand, leans more towards the belief that such risks are inherent, because the natural world always consists of things that are wild and unpredictable. As he says, the natural world is the consequence of an evolutionary trajectory that was not designed, but happened as a result of chance. Cataclysmic events are always going to occur, even when we start designing parts of the natural world.[130]

There is merit to this argument. Both the aurochs and the woolly mammoth went extinct quite a long time ago. And even if we would know a lot about the species involved, ecosystems are still very complex and impossible to predict, as they tend to develop in non-linear ways.[131] It is unlikely that we will be able to control all the consequences of our de-extinction endeavours. Shapiro admits that de-extinction is risky, but argues that conservation success stories prove that taking risks can be very rewarding.[132] However, when the risks are really large, such as possible destruction of the receiving ecosystem, we should wonder whether this is something we should undertake, especially when there are other ways in which the benefits can be obtained.

[124] Merriam-Webster, n.d.
[125] Sandler, 2020a
[126] Bovenkerk, 2012, §2.3.3
[127] Campbell & Whittle, 2017
[128] Sandler, 2019
[129] Sandler, 2014; Campbell & Whittle, 2017
[130] Preston, 2018
[131] Nes & Scheffer, 2014
[132] Shapiro, 2015a

## *3.6 Our proper role within nature*

In the context of de-extinction, there is a second version of the hubris argument.[133] Whereas the form of hubris discussed in the previous section is more concerned with risks of de-extinction, the second form of hubris is a concern about the proper attitude to have towards the natural world and our role in it.[134] Those that are worried about hubris in this sense, usually believe that humanity should take a more modest approach towards nature.[135] Wanting to achieve more control over nature assumes that there is something wrong with nature and that it is up to humans to improve it, reflecting human arrogance, or hubris.[135]

Sandler describes how there are two major views on how we should reinvent our relationship with the natural world in response to the current environmental crisis. The 'respecting the wild view' suggests that we decrease human influence on the natural world and refrain from intentionally designing species and ecosystems. The 'rambunctious garden view,'[136] on the other hand, proposes not to reduce our influence but further technological innovation to repair the damage we have done, intentionally managing, designing and modifying ecosystems and species where necessary in order for them to function in a way that we want, or think is necessary.[137]

The fact that the human species is already deeply affecting the nonhuman environment is often given as an argument for a more proactive and interventionist approach for protecting biodiversity. Sandler calls this reasoning an "appeal to the Anthropocene"[138] and argues that it is fallacious.[137] "It does not immediately follow from the magnitude of human impacts that the proper response is more human control and design."[139] A course of action cannot be derived from a descriptive fact. Indeed, the 'respecting the wild view' observes the same descriptive fact, but suggests a different response.**Fout! Bladwijzer niet gedefinieerd.** In his book *The Synthethic Age*, the environmental philosopher Christopher Preston similarly describes the appeal to the Anthropocene as a "substantial leap in logic."[140] The fact that we have influenced everything on the planet, does not mean that we subsequently have to determine everything as well, he argues.[141] In order to make this more clear, he distinguishes between a retrospective Anthropocene,

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[133] Bovenkerk, 2020
[134] Sandler, 2020a
[135] Bovenkerk, 2012, §2.3.3
[136] Here, Sandler is referring to Emma Marris's book *Rambunctious Garden: Saving Nature in a Post-Wild World* (Marris, 2013)
[137] Sandler, 2020b
[138] Sandler, 2017: S44
[139] Sandler, 2020b: 83
[140] Preston, 2018: 101
[141] Preston, 2018

and a prospective Anthropocene.[142] In the former, the effects of our actions on the planet have been mostly unintentional.[142] What we intentionally decide to do next, is what will determine what the prospective Anthropocene will be like.[142]

Whereas de-extinction raises important issues such as those related to animal welfare and ecological risks, Preston suggests it also represents something deeper. Like many of the technologies now at hand, it provides us with an opportunity to ask to what extent we want to design the natural world.[141] A planet that becomes increasingly synthetic can deeply affect how we view the natural world and our place in it, argues Preston.[141]

> The "ultimate nature of things" has always been assumed to originate in something distinct from us. Its fundamental workings were dictated by larger geological, ecological, or divine forces. We had to accept it for what it was and were compelled to find ourselves a home within its inescapable embrace.[143]

Technologies like de-extinction insert human design into the natural world. This will mean that there is increasingly less in the world we have to accept for what it is.[141] Jason Mark describes the dangers of a world in which everything is gardened. He says that

> as a species we need an Other for some of the same reasons that, as individuals, we have other humans in our lives. They center us. By opposing humans' instincts for control, wild things put our desires in perspective. (...) When all of Earth is our garden, then the world will have become like a hall of mirrors. Each ecosystem will contain some glimpse of our own reflection, and we'll be everywhere, with nothing to anchor us. We'll be lost."[144]

This idea reminds of Cronon's view of Otherness, as something which humbles us and teaches us to set withhold our power to dominate every piece of earth.[145]

Whereas this is something that we should take very seriously, one could wonder, whether de-extinction would really lead to a world that is like a hall of mirrors, or if this is merely a slippery slope argument. De-extinction would certainly increase the amount of things in nature that we have designed. However, a back-bred auroch still has its own will, and can still be seen as Other. There are likely to be still so many wild processes in the animals that we will resurrect, and at the same time, there are so many species left whose origin we had nothing to do with. Indeed, Sandler argues that it is a mistake to think of humanity as "inherent defiler of nature and wildness,"[146] and Cronon similarly says that it is hubristic to think of ourselves as "capable of causing "the end of nature.""[147] Instead,

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[142] Preston, 2017
[143] Preston, 2018: 100
[144] Mark, 2015: 34-35
[145] Cronon, 1996
[146] Sandler, 2020b: 84-85
[147] Cronon, 1996: 89

values such as naturalness and wildness are often believed to be matters of degrees instead.[148] Preston, as well, describes how it is still possible to remain committed to values related to wildness, while at the same time recognizing that we have influenced every inch of the planet.[149] However, at the same time he warns that we should be careful with intentionally shaping the whole planet.[149] "We could, for example, choose to designate some stretches of DNA, or some landscapes, as off-limits to "preserve some important symbols of earth's wildness and independence."[150]

What Preston suggests is the best way to go about the future seems to be something in the middle of the spectrum of the two views Sandler described.[148] He believes that the management of some natural processes will be inevitable. However, we should consciously decide how far we want to take this.[149] De-extinction would be one way in which we would increase the amount of designing we do in our natural environment.[149] It is true that wild processes will remain, also in an ecosystem with resurrected aurochs and woolly mammoths. However, these will be ecosystems that we have designed for certain purposes with animals we have designed to fulfil those purposes, and one could wonder if that is the nature that we want. We should be careful with designing nature too much if we want to preserve the value of a nature whose origin is distant from us.

[148] Sandler, 2020b
[149] Preston, 2018
[150] Preston, 2018: xix

# 4 Case studies: the aurochs and woolly mammoth

Importantly, the concerns described in the previous chapter do not similarly apply in all cases of de-extinction. De-extinction projects differ from each other in important ways, and as a result, some might be more problematic than others. Looking at those differences might help us form a moral judgment about de-extinction. This chapter will discuss the ways in which the de-extinction project of the woolly mammoth and the aurochs differ from each other, and what this means with regards to the moral concerns that have been discussed. The starting point for this chapter will be those aspects which differ, which will be discussed in separate sections.

## *4.1 Technique used*

An important aspect in which de-extinction projects differ from each other is the technique used to bring back the extinct species. For the aurochs, back-breeding is used, whereas the woolly mammoth will be brought back via genetic engineering.

Unlike cloning and genetic engineering, selective breeding is a technique which we have been using for more than 10,000 years.[151] As a result, the process of back-breeding is less likely to accused of being unnatural or hubristic.[152] Whereas some scientists argue that genetic engineering is just a more precise extension of the selective breeding that we have been doing for many years, others see it as a break with traditional breeding methods. Reiss and Straughan, for example, argue that genetic engineering differs from traditional breeding methods in three ways. First, it does not require species to be closely related anymore; we would for instance even be able to insert plant genes into animal genomes. A second difference is the enhanced speed with which changes can be made. And thirdly, the scale in which changes can be made has increased immensely, moving from species used in agriculture to species involved in for example pollution control, medicine, and nature conservation.[151] The latter two differences do not make genetic engineering morally wrong, but show it warrants careful attention.[151] The first difference, however, is often used as a reason to oppose genetic engineering. The products of genetic engineering are often accused of being 'chimeric.' The concern here is with the crossing of

[151] Reiss & Straughan, 1996
[152] Cohen, 2014

species boundaries. This is often put forward as a moral problem, although there is a lot of discussion about the merits of this argument.[153] The argument could be made that it makes species less natural, as their hybridization would probably – and in the case of the Asian elephant and the woolly mammoth today, certainly – not have occurred without human intervention.[154] That something is less natural does not make it morally wrong in itself, but it does increase the amount of human design involved.

Indeed, another way in which genetic engineering is different from back-breeding is in its ability target specific genes. CRISPR/Cas9 can cut genetic material very precisely, like a pair of scissors, which enables researchers to choose exactly the genes that they want.[155] This precision of CRISPR/Cas9 is by some breeders seen as an improvement as it increases the control over the outcome.[155] It also makes it morally more problematic, however, as it increases human design in the natural world and thus increases the extent to which the resulting organisms could be seen as being artefactual.[156] Back-breeding, in comparison, is dependent on the genetic information available in the relatives or descendants of the extinct species, and on processes like genetic recombination which determine which genes are passed on to the offspring. As a result, the outcome is still largely dependent on natural processes.

Genetic engineering is also more problematic because the use of CRISPR/Cas9, which according to Preston introduces significant risks of unintended consequences. The past years have seen a lot of unexpected problems with the technique, such as deletions and rearrangements in the genomes being edited. Whereas this can be defended by suggesting that more work needs to be done to understand all the mechanisms involved, Preston suggests that we could also recognize that the relationship between genes and their expression is not as straightforward as we had thought. The use of genetic engineering is based on a very reductionist view of nature, which neglects the broader context of how genes interact with each other, the organism and the environment. All of these affect the phenotype of an organism, and we should therefore think about organisms in a less reductionist manner. Furthermore, Preston argues, we should recognize that we cannot simply impose our will on living things, which are not merely passive objects but have agency, and can therefore unexpectedly influence on the outcome of an engineering project.[157]

A project like the de-extinction of the aurochs is less prone to the concerns described by Preston, since there is no genetic engineering involved. Back-breeding has a

[153] Bovenkerk, 2012, §2.3.1
[154] Sandler, 2014
[155] Kornfeldt, 2018
[156] See chapter 3, Artefact creation
[157] Preston, 2021

less reductionist outlook and the fact that the agency of the interacting genes, organism and environment will have an effect on the outcome is acknowledged more.

## *4.2 Feasibility of successful release into the wild*

The creation of healthy living individuals is only the first step of de-extinction.[158] The second step is going from one individual to an entire population that can be released into the wild.[158] If, such as in the cases of the woolly mammoth and aurochs (and most other de-extinction cases as well) the goal is to create individuals that can ecologically replace extinct species, it seems difficult to justify the de-extinction of species for whom the only option is to be kept in a zoo.[159] An important concern from a conservation perspective, therefore, is the feasibility that the resurrected population of species can be released into the wild successfully.

In the case of the woolly mammoth, most likely the first few generations of  will be raised in captivity, so that a large enough population is available for release into the wild. The reproductive rates of elephants are very slow, and it is likely to be slow for 'mammophants' as well, so the amount of time spent in captivity is expected to be long. Furthermore, in order for the resurrected species to be able to  thrive in the wild, it is important that it knows how to. It must be able to find food, protect itself from predators, interact with other individuals, find a mate and care for its offspring. This is already difficult for species born in captivity, but even more for a first generation of de-extinct animals, who will have to learn this from humans or a surrogate species. In addition, experience with captive breeding has taught us that not every species does as well in captivity. Elephants, for example, are intelligent and social animals and as a result have needs that are difficult to satisfy in captivity. As a result, they struggle to reproduce, are stressed and more prone to obesity than in the wild. There is little reason to think that elephants containing small fractions of mammoth DNA would do better.[160]

Furthermore, there also needs to be a home available for the resurrected species in order for a successful release into the wild. For species that went extinct because their habitat disappeared, de-extinction will be difficult to justify, and the same goes for those species whose habitat has changed a lot since the extinction took place. An example is the passenger pigeon, also a candidate for de-extinction, whose habitat – the north-eastern forests of North America - has been developed a lot since the passenger pigeon flourished there in the nineteenth century.[161] Both the de-extinctions of the aurochs and mammoth

[158] Shapiro, 2015a
[159] Next to the fact that some might considered this cruel
[160] Shapiro, 2015a
[161] Kasperbauer, 2017

are driven not by a need to bring back a species specifically, but by the need to change a deteriorating ecosystem. This means that there is a physical space available for the species, although it is difficult to predict whether or not it will be suitable enough that the species can survive and thrive, especially since both ecosystem engineers are expected to play an active role in creating their habitat.

With species translocations, a major cause of failure results from the release into unsuitable habitats.[162] It is not difficult to imagine that finding a suitable habitat for extinct species is even more difficult, because less is known about habitat requirements and ecological roles.[162] Furthermore, the longer the time since the extinction, the higher the chance that the ecosystem has changed and as a result, the less chance that de-extinction will be successful.[163] Because most species reintroductions fail it is likely that most de-extinction projects will do so as well.[164] However, there are also several successful reintroduction stories, such as that of the otter in the Netherlands.[165] It might be that de-extinction could lead to successful introductions into the wild as well, although the fact that we would be working with species of which we have not much knowledge, and whose ecosystem has long moved on seems to make this more difficult.

Overall, the chances of successful release into the wild seem higher for the aurochs than for the mammoths. The aurochs do not have to go through a captive breeding phase and will immediately learn to survive in nature reserves – although initially small.[166] Here, they are surrounded by parents and peers that can teach them how to survive in the wild. We do not know that much about the requirements of the mammoth as a species, and the fact it will be genetically engineered can make it even harder to predict what it will need and be like, and whether it will have the effect on the environment that the researchers are hoping for.[167] The fact that back-breeding is a step by step process provides the possibility to learn about the species along the way, and change course if necessary. In other words, the reversibility of (specific steps in) a de-extinction process makes it less risky.

## *4.3 Animal welfare and rights*

As discussed in the previous chapter, the concerns with the animals involved can be divided in concerns with animals rights and animal welfare. Animal rights concerns apply

[162] Seddon, Moehrenschlager & Ewen, 2014
[163] Robert et al., 2017; Sandler, 2017
[164] Shapiro, 2015a
[165] van Norren, 2021
[166] Goderie et al., 2013
[167] Phil Seddon in Kornfeldt, 2018

to all de-extinction practises in which animals are used as a means to an end rather than as an end in themselves. In both the woolly mammoth and the aurochs projects, this is the case. If we can speak about animals rights as a matter of degrees, however, the infringement on animal rights is more serious in the case of the mammoth, in which de-extinct populations of animals will be kept in captivity for many generations. With back-breeding, there is a short stage of forced breeding, but after that, the animals are released into nature reserves where they live according to their own interests.

Concerns with animal welfare occur mainly at three stages: cloning, captive breeding and reintroduction. Cloning is a part of de-extinction through genetic engineering as well as interspecies cloning. There are serious welfare concerns documented around cloning of animals. The stress of egg harvesting and embryo implantation are examples of welfare problems seen with surrogate mothers.[168] Offspring often show health problems, abnormalities and premature death.[169] Whereas refinement of these techniques might be possible, the process of refinement will require a lot more animals to suffer these problems.[170] As mentioned before, the de-extinction project of the woolly mammoth is planning on developing an artificial womb technique to surpass the problems of using surrogate mothers. If this technology will be successfully developed, welfare problems with surrogate mothers could be avoided.

The captive breeding stage that follows cloning will be challenging as well with regards to animal welfare. As discussed in one of the previous sections, elephants do not do well in captivity and with assisted reproduction.[171] It is likely that it would be similarly difficult with their de-extinct counterparts, leading to welfare problems. In addition, animal husbandry will cause difficulties during the stage in captivity.[172] Animal husbandry requires determining the right diet, environment and social conditions, amongst others.[170] It is already difficult to create the right standards for animals that we can observe in the wild. Considering this, it will be likely even harder to do so for animals that we have never seen alive.[170] This increases the chances of suffering during captivity.

The stages of cloning and captive breeding will be followed by reintroduction. The concerns occurring at the reintroduction stage of de-extinction are likely to be similar to those that occur in reintroduction and translocation projects. These are significant: in almost a quarter of reintroduction projects, more than half of the introduced animals die due to predation, disease, starvation and human causes.[170] As discussed earlier in the previous section, successful reintroduction is more likely for the aurochs than it is for the

[168] Campbell & Whittle, 2017
[169] Sandler, 2014; Browning, 2018
[170] Browning, 2018
[171] Shapiro, 2015b
[172] Shapiro, 2015a; IUCN SSC, 2016

mammoths, which will lead to less suffering for the aurochs at this stage, compared to the mammoth.

Cloning, captive breeding and reintroduction are all stages that are part of de-extinction through genetic engineering. Cloning and captive breeding are generally not part of back-breeding programs, although reintroduction or translocation often is. Back-breeding will only have welfare problems at this stage, while for genetic engineering welfare problems occur at three different stages. As a result, animal welfare problems will be more severe for the woolly mammoths.

All in all, when one takes on a strict animal rights perspective, animals should never be used as means to an end, no matter how many lives will be saved, and neither of the projects can be justified from this viewpoint. From a utilitarian welfare perspective, it seems that de-extinction entails significant suffering for individual animals in the cases of cloning and genetic engineering, and in the case of back-breeding at least a reduction in the freedom and autonomy of the animals. On the other hand, both projects aim to save certain species from extinction, either by preventing half-open landscapes from disappearing or by mitigating climate change. These de-extinction projects could therefore avoid future suffering for individuals belonging to these other species, potentially justifying them from a utilitarian perspective. What makes this problematic is that such possible future effects are quite speculative, whereas it is more certain that the animals used for de-extinction will suffer in the process.

# 5 Can de-extinction be ethically justified?

The previous chapters have shown that de-extinction raises many concerns. However, de-extinction is not without value either. De-extinction promises the return of important ecological functions by creating ecological proxies of extinct species. The aurochs will be released into rewilded areas, where they will keep open the landscape and prevent the extinctions of species that depend on these ecosystems. The mammoths would do something similar in Siberia, contributing to the return of the biodiverse mammoth steppe through its unique ability of knocking down trees, which could possibly help mitigating climate change. Next to preserving biodiversity and mitigating climate change, restorations of extinct ecological functions could potentially increase the amount of human-independent processes in nature, which many consider to be of value.

For those who attach great importance to the autonomy of nature and believe that we should take a more humble approach towards the nonhuman natural world, de-extinction might never be justified as a conservation strategy. Ben Minteer, for example, believes that we must accept our moral and technological limits in nature, and keep the practise of nature conservation about restraining our influence on the natural world.[173] He admits that our impact on ecosystems and species is worrisome, but does not believe that this calls for giving up core environmental and moral values such as those respecting wilderness.[174] If one, on the other hand, believes that we can improve on nature as long as the consequence is more biodiversity, de-extinction might always seem like a good idea as long as it is ecologically sensitive. On this side of the spectrum we find Steward Brand, who believes that disturbed ecological balances call for science and engineering.[175] Between these extreme views there lies a whole spectrum of those not sure what to do with technologies such as de-extinction. Here lies the conservationist's dilemma.

In order to answer this dilemma and the research question, 'Can de-extinction be morally justified as a conservation strategy, and if it can, in which cases?,' this chapter will revisit the moral concerns and cases studies that have been discussed. A final judgment will be made about the cases of the woolly mammoth and aurochs, and criteria will be set

[173] Minteer, 2014; Minteer, 2018
[174] Minteer, 2018
[175] Brand, 2010

up that could help determining whether or not other de-extinction projects could be justified.

### *The aurochs and woolly mammoth*

De-extinction cases can differ from each other in significant ways, and moral judgments should therefore be made on a case by case basis. As the comparison between the cases has shown, moral problems with de-extinction are more severe in the case of the woolly mammoth than the aurochs. The mammoth project is more prone to the concern of artefact creation, because it involves a higher degree of design. In addition, it seems to be more hubristic. The mammoth went extinct around 4,000 years ago, whereas for the aurochs this was about 400 years ago. The chance that the ecosystem is not suitable anymore is therefore higher for the mammoth, and our knowledge of the species is more limited as well. This increases the chance of unintended outcomes, making it more hubristic. This is made even worse by the use of the reductionistic CRISPR/Cas9 technique. Back-breeding, a slower step by step processes, provides the possibility to learn about the species along the way, and change course if necessary.

Compared to the aurochs, it is furthermore less likely that the de-extinction project of the mammoth will lead to a successful release into the wild. Organisms created through back-breeding will have parents and peers that will be able to raise them and teach them how to thrive in the wild, whereas the woolly mammoths will lack these learning opportunities. Furthermore, the de-extinct mammoths will be raised in captivity for years, which will likely make surviving in the wild even more difficult. The health problems that are likely to a rise as a result of captive breeding, as well as the lack of knowledge with regards to the needs and behaviour of mammoths – let alone mammophants – will further decrease their chances. The aurochs, on the other hand, do not have to go through a captive breeding phase and will immediately learn to survive in nature reserves with.

For genetic engineering projects, animal welfare concerns are more serious compared to back-breeding projects, although back-breeding is not free from such concerns either. On the other hand, both of the projects might play a positive role with regards to the welfare of future animals, with the aurochs preventing the species in half open landscapes from disappearing, and the mammoth mitigating climate change and thus also species' extinctions. However, these effects are speculative, whereas the suffering of the animals involved in the de-extinction processes is more certain.

For all above-mentioned reasons, I do not think that de-extinction of the woolly mammoth can be ethically justified as a conservation strategy. There are simply too many concerns, the benefits are speculative and it seems that the ecological goals can be achieved without the mammoth was well. It is an incredible shame that we do not have

mega herbivores in many parts of the world, and it is understandable that they are missed because of all the reasons we value biodiversity. However, if we value the autonomy of nature and care about the interests of nonhuman nature, in some situations it would be better to decide to do nothing and accept the loss of a species.

With regards to the aurochs, I am not convinced that it is ethically justified to bring it back either. The moral concerns are fewer for the aurochs, but there does not seem to be a strong ethical imperative for their de-extinction either. The benefits of introducing self-sufficient cattle to keep open the landscape are quite convincing if one cares about preserving biodiversity, but that it is necessary that this species looks and acts as much like the aurochs as possible, is not as compelling. Existing wild cattle species could possibly be introduced into rewilded areas as well, and over time they may become as good at avoiding predators as the aurochs used to be (if they aren't already as good), although maybe in other ways. This would avoid the concerns with active breeding (although not the ones with translocation), which is problematic with regards to animal welfare and increases human design into nature.

### *How to justify a de-extinction project?*

When *would* a de-extinction project be ethically justified from a conservationist perspective? It might be that some de-extinction projects are not prone to many moral concerns, and can promote so many important values that these outweigh the values that are decreased. For this to be the case, to start with, there needs to be a good motivation to bring back a species. When the goal is to restore ecological functioning and there are extant proxies available that can provide this ecological function as well, it becomes difficult to justify bringing back extinct species.

In addition, in order for a de-extinction project to be justified, moral concerns that have been discussed should not apply, or at least not to a large extent. First of all, it is important that de-extinction is not used as a technological fix. As conservationists, we are mostly concerned with those extinctions that result from human actions and therefore de-extinction can only be justified if it is part of a more comprehensive effort that sufficiently addresses the underlying causes related to social and ethical innovation as well. In addition, the creation of a moral hazard should be prevented by making clear that species can never be brought back without loss. Furthermore, in order to prevent the concern of artefact creations, de-extinction goals should not be human-oriented, and the amount of human design should be kept to a minimum. Additionally, projects that violate animal welfare and rights should be avoided as much as possible. This makes the use of cloning and captive breeding as part of de-extinction difficult to defend. This also means choosing species wisely, as not all species will be good choices for de-extinction.

De-extinction will always be risky, but in order to keep the amount of risks to a minimum we should focus on the extinction of recently extinct species, and not use reductive technologies such as CRISPR/Cas9 which increase the risk of unintended consequences.

### *The value of nature, revisited*

Choosing which de-extinction project to justify requires careful consideration of the values that specific de-extinction projects would diminish, and weigh these against those values that it can promote. By choosing projects wisely – which might mean not choosing to do any de-extinction project at all – we can keep the amount of design and intervention into the natural world to a minimum. This is important if we want to preserve the autonomy of nature. Many people experience a sense of humility when they are in nature, of being part of something bigger, and it makes them realize that they are not the centre of the universe.[176] I think that this is an attitude that we really need in the current environmental crisis. De-extinction is one way in which human design into the natural world would be increased, hereby decreasing the autonomy and freedom of nature, and increasing out domination over the natural world. The autonomy and freedom of the natural world are very important to its value. As Martin Drenthen describes it, nature is that what escapes human design, which is exactly why it gives meaning to our lives.[177] I acknowledge that preserving biodiversity is important, because of its intrinsic value but also because we need it to survive. Therefore, I recognize that in some cases, intervention in nature is justified. With regards to de-extinction, however, there seem to be alternatives that can preserve biodiversity just as fine.

A follow-up on the Bucardo story shows us that nature might be able to do more than we had expected, and that in some cases biodiversity and wild processes can be preserved without giving up the autonomy of nature. Six years ago, some Pyrenean ibexes escaped from an enclosure on the French side of the Pyrenees into the cold mountains. The animals managed to survive in the wild, which was believed to be impossible for the subspecies other than the bucardo. Earlier attempts to introduce them had failed, but apparently, nature found her own way. “All this time, I’ve been working towards the goal of bringing ibex back to the mountains. Everything pointed to that being quite impossible without the Bucardo,” Alberto, one of the researchers behind the de-extinction of the bucardo, says.[178] Not only does this story show us that nature is more resilient than we

[176] Clayton in Kornfeldt, 2018
[177] Drenthen, 1996
[178] Kornfeldt, 2018

sometimes think. It also shows us that we might not know everything there is to know about nature, and that practicing a little bit of reverence might not be such a bad idea.

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