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Won't somebody please think of the mammoths? De-extinction and animal welfare

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Abstract

De-extinction is the process through which extinct species can be brought back into existence. Although these projects have the potential to cause great harm to animal welfare, discussion on issues surrounding de-extinction have focussed primarily on other issues. In this paper, I examine the potential types of welfare harm that can arise through de-extinction programs, including problems with cloning, captive rearing and re-introduction. I argue that welfare harm should be an important consideration when making decisions on de-extinction projects. Though most of the proposed benefits of these projects are insufficient to outweigh the current potential welfare harm, these problems may be overcome with further development of the technology and careful selection of appropriate species as de-extinction candidates.

Keywords: De-extinction, animal welfare, cloning, reintroduction

1. Introduction

De-extinction is the process through which extinct species can be brought back into existence[1]. This is usually undertaken with the aim to reintroduce species to the wild and restore ecosystems (Shapiro 2017). The process is controversial, with debates tending to focus on scientific viability, or the ethical issues accompanying such a project, with animal welfare concerns mentioned only briefly if at all. However, as pointed out by Kasperbauer (2017), there is good reason to think that the welfare of the animals involved will be poor. In this paper, I will expand on the potential types of welfare harm that de-extinction programs can cause. This welfare harm should be an important consideration when making decisions on de-extinction projects, and in the final part of the paper I will look at the potential benefits of such projects and argue that in most cases they are insufficient to outweigh the potential welfare harm as it stands. With further development of the technology and careful selection of appropriate species as de-extinction candidates, these problems may be overcome.

1.1. De-extinction methods

There are three methods through which de-extinction can be achieved: selective breeding, cloning and genetic engineering (Cohen 2014; Shapiro 2015). Each of these has different benefits and drawbacks and is useful for different cases. The first of these methods is selective breeding, or back-breeding. In this process, current relatives are selectively bred for those characteristics that defined the extinct species. For example, in order to re-create mammoths, elephants could be successively bred for their larger and hairier variations, until something closely resembling a mammoth is created. There are currently a few programs using back-breeding to attempt to recreate extinct species - projects attempting to bring back the quagga are selectively breeding zebras (Cohen 2014), and to bring back Auroch through selective breeding of modern-day cattle (Shapiro 2017). The process is limited by the availability of sufficiently similar relatives that are still capable of expressing the desired traits.

The second method is somatic cell nuclear transfer (SCNT), or cloning. This requires the nucleus of a cell taken from a recovered member of the species to be implanted into an egg cell of a related surrogate species. This creates a zygote genetically identical to the donor animal of the target extinct species. The zygote is then gestated and birthed by the surrogate animal. A famous example of the use of this process was in the creation of 'Dolly' the sheep. This has

[1] Or something closely resembling the species - see discussion on this point and its implications in Sections 1.2 and 3.3. For the welfare concerns discussed in this paper, the distinction does not play a strong role, though may change weighting of potential benefits, as will be addressed in Section 3.3.

also been attempted for de-extinction purposes, in the cloning of the Pyrinean ibex, or Bucardo, where a clone was made of the last living individual; though this clone did not survive long after birth (Cohen 2014). There has reportedly been some success in using this technique for creating new embryos of the extinct gastric-brooding frog (Cohen 2014). This process is only possible where entire cells of the extinct species are available, which is only the case for very recent extinctions, and where appropriate surrogate species can be identified (Shapiro 2017).

The third de-extinction method is genetic engineering. Here, DNA is recovered from preserved specimens of the extinct species. As it is almost never entirely intact, it is spliced with the DNA of a related species to create the closest possible genetic match to the original target. The spliced genetic material is then used to create a zygote to be gestated and birthed by an extant surrogate animal. Most current work on de-extincting mammoths is using this method, as the remaining mammoth DNA exists only in fragments. It is also the primary method in use for de-extinction of the passenger pigeon (Cohen 2014). This is what Shapiro (2017) considers the "most likely route to de-extinction" (2017, p. 4) as it only requires fragmentary DNA from the target species, which can then be expanded into a whole genome. It is limited primarily through availability of preserved DNA, which rules out long-extinct species, and like the cloning techniques, requires the use of closely related living species both for use of their DNA for gene editing, and as surrogate mothers (Shapiro 2017).

All of these methods for de-extinction are being used in current projects on various species, and each presents potential animal welfare problems, which I will detail in Section 2. This is not merely hypothetical – de-extinction projects are happening now, and the welfare concerns for the animals thus created should be the focus of attention when evaluating these projects.

1.2. Potential issues with de-extinction

In the past few years, de-extinction has become the centre of increasing scientific and philosophical focus, with a number of books and papers published on the scientific feasibility of and ethical issues surrounding such projects. I will summarise these here, before moving on in the next section to examine the animal welfare concerns, which have not yet been given much attention in the literature.

Firstly, there is the question of whether or not the animals created through these methods count as members of the original species. Although they will be genetically similar to the target species, they will still have some differences in genotype, phenotype and development, that may rule them out as part of the species (Shapiro 2017). It is thus uncertain whether the species can really be said to have been brought back from extinction, or whether we have simply

created a new, similar species to fill the same role. This question, and its implications, will be discussed further in Section 3.

Another set of issues relate to scientific feasibility; whether the breeding and cloning methods can even work. Further, if animals are intended for reintroduction, this raises questions as to how we should select species such that they have the highest chance of success when reintroduced (Jones 2014). There are concerns as to whether the necessary environments for release still exist, and whether the animals can undergo the required behavioural training for release (Blockstein 2017). There are also legal issues, as to what the status of the de-extinct and re-introduced animals would be (e.g. native or introduced) and how this would affect conservation and protection legislation (Camacho 2015).

A number of papers have also addressed the ethical concerns of de-extinction projects, across a range of issues. For example, whether this sort of targeted 'precision' conservation is in conflict with a more wholistic form of ecosystem conservation (Adams 2017). There are suggestions that resources spent on de-extinction programs could result in decreased support for conservation of extant species, through loss of actual or potential sources of funding (Bennett et al. 2017). Campagna et al. (2017) are concerned that the discussion of de-extinction could "give the impression that extinction is reversible" and will therefore "diminish the gravity of the human annihilation of species" (2017, p. 48). Davis & Moran (2016) express concern that release of de-extinct species carries the risks of "invasiveness, disease transmission, and unforeseen species interactions" (2016, p. 3) and call for field research using similar surrogate species in order to minimise these risks. Another criticism of the process is that it is 'unnatural' - both in terms of the technologies that are used to recreate the species, and in terms of the nature of the species thus created (Mason 2017). All these questions have already been well-explored and will not be re-examined further here; instead I will now turn to the issues of animal welfare arising from de-extinction projects.

2. Welfare issues

Until recently, what has been absent in discussions of de-extinction is an exploration of the issues relating to the welfare of the animals created through these projects. Although mentioned briefly in many of the papers discussing ethical issues, animal welfare concerns are typically given only a few lines. These usually indicate that these issues are important but should not be difficult to work out, as they are the same sorts of issues that show up in other projects involving scientific research and species reintroduction. For example, Cohen (2014) brings up harm to animals as a potential source of negative utility in considerations of de-extinction projects but

concludes “there is no reason to think de-extinction will cause a large animal welfare problem” (2014, p. 175). Sandler (2014) considers animal welfare concerns as a potential ethical reason against de-extinction projects but concludes “compared with the number of animals already used in research … conservation cloning does not pose a special or very large animal welfare problem” (2014, p. 358). Although he acknowledges that research should take care to minimise suffering caused, he thinks “the animal welfare concerns it raises do not significantly differentiate it from many other research and conservation practices involving animals” (2014, p. 358). Rohwer & Marris (2018) point out that “creating a *mammoth* is morally *permissible* . . . provided that suffering is minimal” (2018, p. 2, italics in original), and go on to describe some of the concerns with cloning, surrogacy and rearing; though again, follow Sandler in dismissing these as not much different from those in other similar conservation practices. Greely (2017) describes the potential welfare problems associated with cloning technology but considers that “the risks of de-extinction are not substantively different from those associated with gene editing” (2017, p. 34). Friese & Marris (2014) briefly describe some of the welfare concerns in the creation and rearing of de-extinct animals, and argue that “questions regarding animal care need to be understood as a crucial part of de-extinction experimentation, rather than downstream concerns” (2014, p. 2), however they conclude that these issues can be addressed through “a social science approach based upon the current realities of cloning, genetic engineering, back breeding, and species preservation today” (2014, p. 3).

Only Kasperbauer (2017) has really emphasised the importance of animal welfare considerations in making decisions about de-extinction programs, labelling it as “the most critical challenge for de-extinction” (2017, p. 1). He argues that “the current state of de-extinction technology provides good reasons to think the lives of de-extinct animals will indeed be full of suffering” (2017, p. 6) due to problems with cloning technology and reintroduction, and briefly outlines some of the ways in which these potential harms could come about. Here I will examine in detail exactly how and why these situations are likely to be harmful to animal welfare.

Although it is true that many of the welfare issues are continuous with those affecting other areas of animal research and conservation, I argue that de-extinction creates special issues for animal welfare that need to be considered when evaluating such projects. Welfare issues can affect the de-extinct animals, other animals used in the process (e.g. surrogate mothers) and the wild animals that will be impacted through reintroduction (Cohen 2014). In particular, there are welfare issues surrounding the cloning procedures when these are used, and in the process of captive rearing and reintroduction, beyond those usually faced by zoos or conservation

bodies doing this sort of work. This is in large part due to the lack of knowledge about these species and their requirements.

2.1. Welfare issues with cloning

In the first instance, there are issues surrounding the cloning technology used in both SCNT and genetic engineering. These will not be a problem for back-breeding projects, though this method will face a few problems of its own. So far, the use of cloning has been problematic for animal welfare, with cloned animals showing rapid aging, ongoing health problems and premature death. "Cloned animals suffer from impaired health, including placental abnormalities, foetal overgrowth, prolonged gestation, stillbirth, hypoxia, respiratory failure and circulatory problems, malfunctions in the urogenital tract, malformations in the liver and brain, immune dysfunction, anaemia, and bacterial and viral infections" (Gamborg 2014, p. 6). Fiester (2005) outlines the different ways in which cloning procedures can have negative impacts on animal welfare – through the suffering inherent in the cloning procedure, gestational problems with surrogates, ongoing health of cloned animals and the future suffering cloned animals might endure through research, housing etc. These procedures are associated with miscarriage, stillbirth, early death, genetic abnormality and chronic disease. As the success rates (in terms of live birth) for even the most effective programs are only 5-12%, this creates a lot of excess donor procedures and surrogate pregnancies. As cloned foetuses show a higher than average birth weight, caesarian deliveries are also often necessary. Those offspring that are delivered alive show huge mortality rates, due to conditions such as developmental abnormalities and lung, heart and liver problems. The US Humane Society has advocated for a ban on these procedures due to the high incidence of welfare problems.

Take the famous Dolly, the first ever successfully cloned individual. Dolly was plagued with health problems, such as arthritis and lung disease, and died at six years, only around half the normal life span of a regular sheep of her kind (Williams 2003). These sorts of problems only increase when using the technology to create and gestate extinct animals in close relatives rather than conspecifics, with low success rates and high levels of health problems and abnormalities in both the surrogates and foetuses in interspecific procedures (Sandler 2014). A Pyrenean ibex cloned from the last individual, died of a lung defect within minutes of birth (Cohen 2014).

Surrogacy can give rise to the problem of maternal-foetal incompatibility, which can be problematic to both the surrogate mother and the gestating foetus (Fiester 2005). Similarly, there can be birthing complications when the target animal is larger or differently shaped than

the surrogate, as would be the case with - for example - elephants carrying mammoth babies. Surgical delivery is the likely option in these cases, but surgery on an elephant is difficult and the chance of complications during surgery or recovery is high. There are also the chances of maternal rejection of the unusual offspring, creating potential social isolation. The lactation of the surrogate mother may not be appropriate for the offspring, creating nutritional and health problems. Shapiro (2017) points out that we need close relatives of the extinct species in order for the process to be successful, and these may not often be available; the less closely related the surrogate species, the higher the chances of problems arising.

Back-breeding can run into similar problems. If selecting for larger or somewhat different individuals within the population, we again have a risk of gestational complications (though lower than in the surrogate cases) and maternal rejection of unusual offspring. Back-breeding will also usually use a very small founder population, and so creates significant risk of inbreeding and the associated health issues (Shapiro 2017).

Although these issues may be reduced with further research into the technology - looking for where the problems in development are occurring and repairing them - this further research will require the production of animals fated to suffer these physical and psychological problems. Some of these problems may be the same as those facing other animals created through these methods for research or agriculture, but some will be unique to de-extinction, particularly due to the requirement to use other species as surrogates. Additionally, the defence that these problems occur in other areas of science (the 'accepted practice standard') is not a strong one. The fact that one set of practices matches another provides no real justification if the first set of practices is also ethically problematic (Fiester 2005). Any project which uses the technology should be independently assessing the potential harms. These other applications are deemed acceptable in large part because of the perception of gains in other areas, so this response can only apply where there is sufficient justification of the benefits, to outweigh the potential suffering caused. This trade-off will be examined in Section 3.

2.2. Welfare issues with captive rearing

As discussed, there are potentially serious welfare problems with the use of cloning technologies as they currently stand. However, refinement of the procedures can possibly reduce or remove most of these problems over time (at least those involved with cloning itself – issues of maternal/foetal incompatibility seem potentially more serious). Of greater concern, and far less obviously surmountable, are the issues surrounding the rearing and release of de-extinct animals. Shapiro (2015) points out that "from an animal welfare perspective, the captive

breeding stage is likely to be one of the most challenging steps of de-extinction" (2015, p. 195). These are in large part practical issues as to the feasibility of such practices, but as their failure harms the welfare of the animals under consideration, they are also strong welfare concerns. Again, these have largely been dismissed as the same issues that surround any breeding and reintroduction programs, something zoos have been addressing for many years (e.g. Beck 1995), but this does not mean they do not need to be addressed independently for these projects. Additionally, there is good reason to think that de-extinction programs are going to have a unique set of challenges arising from lack of knowledge and lost ecological conditions.

Breeding and rearing any animal in captivity requires a set of husbandry standards in order to succeed. These include detailing the recommended diet for the animal, appropriate housing conditions (such as temperature, shelter, access to water), social conditions, behavioural requirements, known health issues and how to treat them, among other information. For most captive animals, collection and collation of such information has taken decades, drawing on knowledge of the living conditions and habits of wild counterparts, or closely related species, and much trial-and-error on the animals in captivity – often resulting in poor health and short lifespans in the early members of captive populations. As an example, historically reindeer were notoriously difficult to keep in captivity, consistently suffering ill health and dying young. Eventually it was found that in the wild, their diet included a large amount of lichen, which provided essential nutrients (Steen 1968). Addition of these to the captive diet fixed many of the problems previously encountered. Without the ability to check this in the wild population, this problem could not have been fixed and in the meantime would have led to ongoing suffering.

If it has been this difficult to create husbandry standards for the animals we have held in captivity for many decades, sometimes even centuries, with access to research on their wild relatives, it will be infinitely harder to do so for animals for which we have no such information. In some cases, we might be able to use modern relatives as a starting-point: for example, quagga are likely (though not certain) to have similar requirements to zebra. In other cases, the species may have gone extinct recently enough that we still have access to some relevant information. For example, the thylacine - which has been gone less than a century and was frequently held in captivity prior to this - is a species for which we are likely to still have ecological and husbandry data. For other species, this will be much more difficult. Take the de-extinction flagship, the mammoth. We have no good reason to believe their diet, habits or environment will at all closely resemble that of modern-day elephants. They are a vastly different species, which lived in a vastly different environment. Paleontological evidence is

scarce, and given the slow production rate of large animals like these, trial-and error, even if considered ethically acceptable for research purposes, is impractical. In pointing out that de-extinction would give us the ability to study and learn about extinct animals, Rohwer & Marris (2018) also demonstrate that there is a lot we don't know about species like mammoths – "how long do they nurse? What time of year do *mammoths* mate? How intelligent are *mammoths* as compared to elephants?" (2018, p. 7, italics in original). Seddon et al. (2014) list some of the types of knowledge we need for successful rearing and reintroduction – "knowledge of former distributions, social structure and behavior, diet, reproduction, parental care and growth, interspecific interactions, and biotic and abiotic habitat requirements is required" (2014, p. 143). Although they are somewhat confident that "valuable clues may be obtained from the biology and ecology of extant species that may be nearest living relatives or otherwise occupying a similar ecological niche" (2014, p. 143), for long-extinct species, this is likely to be a much more difficult project than this suggests.

Even if we are able to determine what the appropriate conditions should be, there may also be large problems with providing them. Take the mammoth example again. If mammoths are anything like their elephant relatives, they live in large social groups of mixed age and sex. However, in the early stages of de-extinction projects all we will have are numerous juveniles. These may get some of their required social contact with elephant surrogates, but elephants are unlikely to have the required behavioural repertoire and social 'vocabulary' to match their mammoth companions. Provision of appropriate environmental features, and required dietary items could also prove intractable if these are no longer available.

2.3. Welfare issues with reintroduction[2]

Above, I have discussed the problems of housing the de-extinct animals in captivity. Just raising them to an age that they are suitable for release may prove to be impossible, and this is a huge welfare concern – the animals are likely to be malnourished and in poor health, with potential psychological and behavioural deficits. But in most of these programs, the animals are also destined to be released back to the wild (Shapiro 2017)[3], and as such require rigorous behavioural conditioning for this process. Seddon et al. (2014) argue that "de-extinction is a

[2] Though the use of the term 'reintroduction' here and throughout the paper implies the released animals would be of the same species as the extinct ones, this is not meant necessarily as an endorsement of this view, but is rather following the common usage in the literature. The welfare issues discussed are the same regardless of whether or not the releases can be classified as reintroductions.

[3] Not all de-extinction projects aim at releasing animals back to the wild (Sandler 2014), and those which simply aim to create animals to hold in captivity for research or exhibition will not face this set of welfare problems, though the others, particularly those in Section 2.2, will still apply.

conservation translocation issue" (2014, p. 140) and thus will require the same considerations and hold the same risks. Jørgensen (2013) summarises the IUCN guidelines for reintroduction – "background studies to allow identification of the species' habitat requirements, identification of lessons learned from prior reintroduction projects of similar species, evaluation of potential sites within the former range of the species, selection of appropriately diverse genetic stock, and an assessment of the socioeconomic context of the project" (2013, p. 719). It should be immediately clear that for de-extinct species, we will not have the means of obtaining most of these answers, as indicated in the previous section. Harrington et al. (2013) provide a detailed flow-chart of welfare considerations in reintroduction projects, demonstrating the huge number of considerations at play and knowledge required for such projects to go ahead successfully. A lot of these issues will be particularly salient for de-extinction projects, as the required data will not be available. Without this information, we have little chance of successful reintroductions, and this will lead to decreased welfare for reintroduced animals.

There are a number of potential animal welfare issues present in all reintroduction projects. These include mortality, disease, post-release stress and human conflict. Almost a quarter of reintroductions have mortality over 50%, due mainly to predation, traffic and other human effects, and disease and starvation (Harrington et al. 2013). Beck (1995) found that only 11% of the reintroduction programs he studied were successful in creating self-sustaining wild populations. Our lack of knowledge about de-extinct species and their ecology means these numbers are likely to be even worse for de-extinction projects. Harrington et al. (2013) looked at ways of measuring and monitoring welfare of released animals (e.g. health, condition, behaviour) and the types of supportive actions that may be used to improve welfare, such as health screening, pre-conditioning and provision of artificial food and shelter. These again all require knowledge of the species in order to succeed. Harrington et al. (2013) also noted that captive-bred animals were more likely to fail to cope after release than wild-caught animals. This is a problem for de-extinction as all animals in these projects will be captive-bred.

There are also concerns for the welfare of other wild animals that will come into contact with the released species, through habitat alteration, resource competition, predation or aggression (Seddon et al. 2014). This may be managed to some degree by careful choice of species for de-extinction (for example, large slow-breeding animals that can be more easily tracked) (Seddon et al. 2014), but lack of knowledge about the species will still make potential impacts hard to predict.

Even the preparatory training procedures for release can also be detrimental to welfare, as has been discussed for captive breeding and release programs of extant species (Beck 1995). They require training and conditioning animals to tolerate the reduced conditions of the wild – lack of shelter, exposure to parasites, lack of food, avoidance of predators, social interactions with unfamiliar conspecifics etc. All of these conditions require a reduction in welfare as compared to the captive environment. Beck (1995) looks at some ways of improving post-release success and welfare – presence of a wild-born 'teacher' for natural behaviours, post-release support and monitoring, and careful study of which of the stressful pre-release conditions are actually required to help survival and flourishing. All of these will be extremely difficult to provide in a de-extinction context. For example, we are unlikely to know what sorts of wild conditions these animals need to be acclimatised to and will not have access to suitable model animals to act as 'teachers'.

In particular, training the necessary behavioural repertoire for a species that has never been observed in the wild seems a potentially insurmountable task. "It is unclear how emergent social behaviours would survive the de-extinction process" (Jones 2014, p. 21). The ways in which these animals interact with their environment, find and extract food, find and make shelter, and interact with one another and other wild animals, are all unknown. Turner (2017) points out that most of the candidate species for de-extinction programs are large, charismatic vertebrates, such as mammoths or passenger pigeons, and these are precisely the sorts of animals for which the concerns are likely to be most pronounced, due to their behavioural complexity.

Getting the preparation wrong before releasing an animal can have disastrous consequences, as has been seen in countless reintroduction projects performed with animals that have wild counterparts to study. In fact, the high rate of failure of such projects has led to them generally falling out of favour as conservation initiatives. Where animals cannot be properly prepared, when released they will suffer and are likely to die, with no ecological benefit. This is, of course, a huge welfare concern. The IUCN regulations for reintroductions state "the welfare of animals for release is of paramount concern through all these stages" (IUCN 1998, p. 9). Given the problems with reintroduction programs even for well-known species, it is highly likely that de-extinct species will suffer during the process. At the very least, it will require very careful assessment of potential candidates, to minimise these concerns (Seddon et al. 2014).

2.4. Measuring welfare

A final concern is that we don't have any good way of measuring what sorts of welfare harms are occurring in these projects. As I will describe in the next section, it is possible that the welfare harms described could be offset by benefits in other areas. But even if we are able to develop a framework that allows us to determine how much welfare harm is acceptable for gains in other areas, it is not at all clear that we can get a strong sense of the level of harm that is occurring. Making a decision about an action based on its harms and benefits requires at least a basic approximation of the degree of these harms and benefits, and this may be extremely difficult for the welfare of de-extinct species. Measurement of welfare requires using physiological and behavioural indicators that are usually specific to the species, and calibrated through testing of other individuals. Our lack of knowledge of the normal behavioural and physiological parameters for these animals mean that we can make only very rough (and potentially anthropomorphised) judgements as to the welfare of the animals we are creating. There is also not a large pool of individuals that we can test to develop such indicators. Use of welfare indicators from other species may suffice, but may also be greatly misleading if the species differ in the particular behaviours or physiological markers used. This may then have a large impact on the trade-off matrices we are considering.

2.5. The moral status of de-extinct animals

It is clear that there are many strong potential concerns for the welfare of the animals used in and created by de-extinction projects. Perhaps, though, we might think that these are not problematic as the animals do not fall into the right category to require our moral concern. The degree to which we should be concerned about the welfare of reintroduced de-extinct animals mirrors the discussion about de-domestication – the 'rewilding' of domesticated animals (see e.g. Gamborg et al. 2010). There is a tension here about whether the animals should be considered as wild animals, or domestic animals, as these categories carry with them different ethical and legal implications. Domestic animals tend to be considered at the level of the individual animal, with welfare considerations in the forefront, while for wildlife the consideration is at the level of species or population (Gamborg et al. 2010) and it is generally considered acceptable to compromise animal welfare somewhat if there is an overall species-level or conservation benefit. Norton (1995) argues that wild animals, for the most part, do not need to fall within the human moral sphere, and that in fact because we value their wildness, we choose not to interfere in their lives. "It is not this *content* of animal experience but the *context* in which we encounter it that determines the strength and type of our obligations" (1995, p. 106, italics in original). The level of our interference in the lives of animals

determines our responsibilities towards them. Captive-bred exotic animals, neither wild nor domestic, fall somewhere between these boundaries.

A difference between usual considerations of management of wild animals and of de-extinct animals is that we are not just dealing with animals as 'moral patients'; the additional fact that we have *created* them places on us extra duties of care (Cohen 2014). Gamborg et al. (2010) also stress the difference between animals which humans have been directly involved in creating or rearing, for which we should assume responsibility, as opposed to those we have not: "Because humans are responsible for the very existence of domestic animals … and because the latter often render the relevant animals dependent and vulnerable in ways wild animals are not" (2010, p. 72). As de-extinct animals are created by us, often for our own ends, and spend at least the early part of their life in our care, their welfare should be our concern.

3. Weighing up potential benefits

I have outlined some of the ways in which de-extinction efforts are likely to be harmful to the welfare of the animals involved. These are big problems, in some cases possibly insurmountable, and it is almost inevitable that these programs will result in animal suffering. Even if there are some positive experiences in the lives of the de-extinct animals, it seems likely that these will be far outweighed by the physical and psychological problems described above and most de-extinct animals would not have what would be considered 'lives worth living'. However, this does not necessarily mean we should not engage in such programs at all, as there are other potential benefits to weigh against the welfare harms.

Animal welfare should be a strong ethical consideration in any project that impacts it and most authors in the area agree that animal welfare is an important concern. Cohen (2014) claims that "beyond a certain level and probability of harm de-extinction may cause, we should refrain on moral grounds from performing it, despite sacrificing greater utility" (2014, p. 175). Sandler (2014) takes a milder approach, concluding that "while animal welfare concerns must be addressed, they do not justify abandoning deep de-extinction" (2014, p. 358). Kasperbauer (2017) concludes that de-extinction is "still permissible … but only if it can overcome the challenges I identify" (2017, p. 2), which particularly refers to the animal welfare cost and takes the strong view that "the ethical permissibility of de-extinction projects would be limited by their ability to ensure that the individuals brought back would not have lives full of suffering" (2017, p. 7). Rohwer & Marris (2018) similarly argue that de-extinction would be permissible "if and only if suffering is minimal" (2018, p. 1). But as important as welfare considerations are, they are not the only considerations in play. There are many potential values

which will be positively or negatively affected, such as environmental and human values, and these should be considered against one another. This means that when considering the ethical permissibility of the de-extinction program, we must look at the potential benefits and how these might sit against the welfare harms.

This sits within a larger dialogue about under which conditions it may be acceptable to cause harm to animals for some other benefit. It is beyond the scope of this paper to assess this question in any meaningful way. I will assume that the extreme positions – that it is never okay to cause harm to any animal unless it is to benefit that animal itself, or that it there is no problem in harming animals in pursuit of some human gains – are the least plausible, and that there will be at least some conditions under which we consider such harms acceptable. We then need to establish what the real gains of such projects will be, as well as the level of harm that will be occurring (as mentioned, not necessarily an easy task), and make some attempt at weighing these concerns. Norton (1995) notes that there is unlikely to be a single moral measure on which we can make such decisions. Instead we should be moral pluralists, with differing values in competition, and between which we must adjudicate – "we value many things in different ways, and these differing values are sometimes in conflict" (1995, p. 104). He continues that "we have an obligation to minimize the suffering of individual animals in some situations and that we have obligations to emphasize species protection in other situations. The problem is to explain coherently and effectively how to tell the difference between these situations" (1995, p. 104). Diehm (2017) points out that the 'individualistic' ethic used in animal welfare concerns will not be the only important value in conservation considerations and "the broader conversation about de-extinction is likely to take place on terms substantially more holistic" (2017, p. 26), taking into account species value as well as individual. Where there is a sufficient gain of some other sort, we might accept the welfare harms of these projects.

The potential gains of de-extinction projects fall into four categories. These are: ecological – the improved quality of ecosystems with restoration of keystone species; aesthetic – human preference for the presence of such species; restorative – that we are in some sense righting the wrongs we have committed in sending such species extinct; and scientific – leading to advancement of knowledge and technology. Several authors have analysed these potential benefits. Cohen (2014) and Sandler (2014) provide in depth analyses of all of these and both conclude that none of these provide sufficient justification for such a project. More recently, Rohwer & Marris (2018) assess potential benefits and conclude that human benefits are the most likely justification, but cannot overrule animal welfare concerns. Sandler (2014) argues that "deep de-extinction does not address any pressing ecological or social problems, and it

does not make up for past harms or wrongs. As a result, there is not a very strong ethical case (let alone an ethical imperative) for reviving long extinct species or developing the capacity for doing so … taking on significant costs and risks or funnelling scare resources to pursue it is not justified … deep de-extinction is in many respects a luxury. It is fine to pursue it if people want, so long as it does not interfere with or compromise ethically important things" (2014, p. 359). Greely (2017) describes the proposed benefits as "vague and insubstantial" (2017, p. 35) in comparison to other potential uses of resources to solve environmental and human health issues. Here I will run through some of the commonly proposed benefits of de-extinction projects, and the objections raised against them, to assess whether they are likely to be sufficiently great to outweigh the potential welfare harms; concluding that it is unlikely that any will be sufficient as things currently stand.

3.1 Ecological benefits

The first, and probably strongest justification for de-extinction is ecological: that it can help improve the environment through restoring ecosystems. This is what Kasperbauer (2017) refers to as the 'instrumental' value of de-extinct species. It is a commonly held view in conservation biology that we have an obligation to sustain natural processes, and this obligation will offset some animal welfare harms (e.g. Norton 1995). There are two different strands to this justification and the replies to it – whether we should be aiming at ecosystem restoration at all, and whether de-extinction is the best process to achieve this.

On the first point, it is not obvious that ecosystem restoration is the right target for conservation ecology. Ecosystems are dynamic, constantly changing, and there may be no principled way for choosing some historic state of the ecosystem as the one we should aim at restoring (Davis 2000). Under this view, there is no objective standard of 'ecosystem health' that we can aim at, and all these efforts would merely be based on an arbitrary judgement of the ideal state of an ecosystem from a human point of view (Rohwer and Marris 2018).

Even if we were to accept the goal of ecosystem restoration, and were able to set an ideal target state, we don't know enough about ecology to predict whether our actions in this regard may be successful. Cohen (2014) concludes: "Although our analysis supported the essential and actual possibility of de-extinction's ecological benefit, probable changes to species' environment since extinction and the resultant risks reintroduction may pause to ecosystemic integrity will likely make the overall ecological value of de-extinction quite uncertain in most cases" (2014, p. 169). Single-species de-extinctions may be ineffective in restoration, as ecosystems require interactive networks of species and the target species would thus likely

"need to be brought back with a cluster of other species" (Kasperbauer 2017, p. 5). Most of the species are unlikely to thrive in the wild without assistance (hence their previous extinctions). De-extinct species may fail to provide the intended ecological functions, instead merely serving as "functionally ineffectual eco-zombies" (McCauley et al. 2017, p. 1004), as ecosystems can change rapidly after extinction and the functional niche may not remain. Robert et al. (2017) are similarly concerned about possibility for success, due to problems of limited genetic variability and ecological divergence of the species from the ecosystem.

In terms of a conservation 'last resort' or safety net, de-extinction projects are likely to be of limited benefit, as they will not address the causes of species decline, and are probably not the best use of resources in this area (Sandler 2014). There are strong reasons to think de-extinction projects are unlikely to succeed in restoring lost target ecosystems. At the very least, this justification is only as strong as the likely success of the de-extinction project in restoring the target ecosystem, which relies on a deep understanding of the ecology of the species, the availability of appropriate habitat, removal of the original causes of extinction and the role of the particular species within the ecosystem (Kasperbauer 2017; Seddon et al. 2014).

3.2 Aesthetic benefits

The second proposed justification for de-extinction projects is based on human values – the value we place on the resurrection of the species. De-extinction and the animals created could be a source of 'wonder' or 'awe' that in itself would hold intrinsic value (Cohen 2014). "It is difficult to quantify the pleasure and excitement that seeing a *mammoth* family might cause. But it is probable that a very large percentage of humans would rank the experience as something of immense value—something, not to put too fine a point on it, mind-blowing" (Rohwer and Marris 2018, p. 8, italics in original). The impact of these experiences may even be improving for those who experience it – increasing commitment to conservation values, for instance (Rohwer and Marris 2018). Kasperbauer (2017) cashes this out as the 'existence value' of the de-extinct species – the fact that humans value these species for their existence alone, and not just for their instrumental ecological value. He concludes that while this value may be present, it does not give us strong reason to think it outweighs the suffering caused through de-extinction programs: "existence values for species should not be ignored, but they also do not dictate one way or another on the moral permissibility of de-extinction" (Kasperbauer 2017, p. 9). The same holds true for any potential commercial benefit that may be obtained from creation and display of de-extinct animals – though there is the possibility that people would be willing to pay quite large sums to have these experiences, commercial benefit is not the sort

of value that should influence moral deliberation.

3.3 Restorative benefits

The third potential justification is that de-extinction is in some sense a matter of justice – something we 'owe' to the species we have driven extinct; a responsibility we have to resurrect those species for which we were the cause of their extinction. This relies on the assumption that species are the kinds of things which are able to hold such claims, which is unconvincing (Rohwer and Marris 2018). Cohen (2014) bases this in the idea that the good of individual animals is built on what is good for the species, but this is not persuasive. Kasperbauer (2017) argues against this view, pointing out that "individual sentient animals have morally relevant interests because they can experience pain and suffer … by contrast, a species, as a whole does not experience pain or pleasure. This makes it difficult to say that a species can actually be benefitted or harmed in the same way [as] individual animals" (2017, p. 5). He concludes that "justifying de-extinction on the grounds that it meets species' interests in this way should certainly be seen as illegitimate" (2017, p. 6). Sandler (2014) also dismisses this possibility as species, and the natural world in general, are not the sort of thing to which we can owe such claims – "therefore de-extinction is not well justified on restorative or reparative justice grounds" (2014, p. 356).

There may still be some ways in which we can capture the thought that de-extinction helps us right ecological 'wrongs' we have previously committed. However, even if we could make sense of our duties towards extinct species, de-extinction may not be a way of discharging them. As many authors have pointed out, the animals created may not belong to the same species as the extinct species – Shapiro (2017) describes them as "proxies, not copies" (2017, p. 5). The de-extinct animals would be genetically different (Shapiro 2017), behaviourally different (Blockstein 2017), and ecologically different (Beever 2017) than the target extinct species. Both selective breeding and genetic engineering result in animals genetically different from the target species, without a clear line of descent from ancestors. For both of these methods, as well as cloning, the different epigenetic factors, rearing environment and ecological interactions will result in different phenotype (Shapiro 2017). Regardless of which species concept one employs, the genotypic and phenotypic differences between de-extinct animals and their extinct ancestors are likely to be sufficient to undermine the claim to species membership. If this is right, and we do not have the same species, it is difficult to justify that de-extinction has benefitted or provided justice to the extinct species.

Although the claim to restorative benefits towards extinct species is weak, it is possible that

such benefits could be owed to human groups or societies that have been harmed by the loss, such as those with historical cultural or economic ties to the species. This is not an idea that has been explored in the literature, but provides a more plausible claim to justice benefits than to the extinct species themselves, particularly in the case of more recently extinct species. This would require analysis of the particular cases to determine the level of harm and benefit, but in some cases such claims may provide a reason worth weighing against animal welfare concerns.

3.4 Scientific benefits

The fourth justification or benefit of de-extinction programs is the benefit of the science itself – the value in advancing our scientific knowledge and creating new technology. Sandler (2014) considers this to be the primary benefit of de-extinction programs. Similarly, Rohwer & Marris (2018) promote anthropocentric benefits, including scientific knowledge, as the primary goods of de-extinction projects. These projects could push forwards scientific knowledge in terms of the techniques and processes used, as well as the ability to study and understand the de-extinct animals themselves, and the subsequent ecosystem changes (Rohwer and Marris 2018). These human benefits of knowledge accumulation are not strong ethical reasons, "therefore legitimate ecological, political, animal welfare, legal, or human health concerns associated with a de-extinction (and reintroduction) must be thoroughly addressed for it to be ethically acceptable" (Sandler 2014, p. 354). There is a stronger case where research and understanding could provide more direct benefits to humans, such as improvements in medical research – for instance, suggestions that research into de-extinct gastric brooding frogs could improve understanding of infertility in humans (Zimmer 2013). Concrete benefits to human lives could be weighed against animal welfare concerns in the same way that current medical testing does, but would require a convincing case that the benefits are likely and of a degree to outweigh welfare harms.

There are possibly other benefits for the technologies currently developed for de-extinction. They could be used in conservation projects for extant species, such as genetically engineering species to tolerate new environmental conditions caused by climate change (Kasperbauer 2017) or the 'genetic rescue' of endangered species with low genetic diversity (Rohwer and Marris 2018). "The scientific knowledge and progress that will likely occur also has a great potential to help currently endangered and threatened species" (Rohwer and Marris 2018, p. 8). As these would be improving the quality of life for currently existing animals, there would be an obvious benefit to individual welfare that may offset other welfare problems. However, this would only provide a reason to develop the techniques in these other contexts, not for de-extinction itself.

3.5 Creating future animals

One more potential argument in favour of de-extinction projects of this kind is that they may give rise to many future animals, who will have good lives. Kasperbauer (2017) quotes Brand – "if you can bring bucardos back, then how many would get to live that would not have gotten to live?" (in Kasperbauer 2017, p. 6). This future benefit might then compensate for the current suffering caused. There are two parts of this argument – the presumption that future animals may actually have good lives, and that if they do then this will can outweigh present suffering. In regards to the first claim, it is not clear that the future animals will have sufficiently good lives, due to many of the problems described earlier for rearing and reintroducing animals. "At the very least, they need to present evidence that that lives of future individuals will be good enough to justify the suffering of the first individuals brought into existence. If none of these lives are worth living, then de-extinction is clearly impermissible" (Kasperbauer 2017, p. 7).

The second claim is a controversial one – it is not generally accepted that the potential future lives of others is a moral good, and certainly not one that outweighs current suffering. To paraphrase Narveson (1973), we want to make people happy, not make happy people. While we may have obligations not to bring into existence individuals who will have lives of suffering, we have no such mirroring obligation to bring into existence individuals who will have lives worth living (McMahan 2002, p. 300). This means that the future good lives of other animals could never outweigh the suffering of the initial animals. "Many ethicists would be reluctant to accept that the possible existence of future animal lives could justify intense suffering for the first individuals" (Kasperbauer 2017, p. 6). Kasperbauer (2017) concludes that the justification for creation of future lives could only work if the lives of the first animals are not full of suffering - "at the very least … the initial individuals could be guaranteed a certain level of well-being – in common parlance, a 'life worth living'" (2017, p. 6) and this seems unlikely, for the reasons discussed in Section 2.

4. Conclusion

I have shown here that none of the proposed benefits to de-extinction programs appear sufficient to outweigh the cost in terms of animal welfare, at least not as it currently stands. This is without taking into account other potential costs, such as economic costs of the research, opportunity costs in terms of other conservation projects that may have instead been funded, risks of harm to existing ecosystems and human populations from release of new species and the potential decrease in urgency of conservation efforts if extinction is seen as reversible

(Camacho 2015). These additional costs give even more weight to considerations against these projects. Sandler (2017) points out that the way in which we consider these trade-offs will depend a lot on our starting point: "is the presumption that a de-extinction effort ought to be permitted to go forward unless there are compelling reasons, such as those that would emerge from a conservation cost–benefit analysis, against doing so? Or is the presumption that a de-extinction effort ought not to be permitted unless there are compelling reasons, such as those that would emerge from a conservation cost–benefit analysis, in favour of doing so?" (2017, p. 2). Which of these starting points we take will influence how strong the reasons for or against need to be in order to be decisive. The strong evidence for welfare harms gives us a presumption against de-extinction and thus would require compelling reasons in favour in order to outweigh these costs – reasons which we do not currently seem to have.

What this means is that we should at least wait to begin. These projects are, for the most part, not time-sensitive. The targeted animals will not become more extinct the longer we wait. Giving some more time would allow for improvements in the technology that may help reduce these welfare harms. Though the course of making these improvements might still require the use of animals that would be harmed, the number of animals could be smaller, and the larger-scale de-extinction projects could then take place in future with reduced suffering. For more recently extinct species, such as the thylacine, the problem is more pressing, as we may want to bring the species back before the ecosystem changes too much to support them. The likelihood of significant welfare problems, and the lack of strong justification for the projects, suggests that if such projects should go ahead at all, careful attention needs to be paid to the selection of candidate species in order to minimise the risks of suffering, and maximise benefits.

'Shallow' extinctions such as thylacines may be far better candidates for de-extinction projects than 'deeper' extinctions, such as mammoths. For the latter, our lack of knowledge, and changes in ecology, are likely to lead to greater welfare problems, as well as less chance of successful projects. Rohwer and Marris (2018) support this conclusion: "certainly, we believe that the case for bringing back very recently extinct animals is much stronger. Where their habitats and ecological interactions are still available, their return can be justified in the same way as a reintroduction of a locally extinct species" (2018, p. 12). For the projects to have the strongest benefit, and greatest potential to outweigh welfare concerns, these should be species which have a high chance of successful reintroduction, and those which are likely to pay the largest role in restoration of damaged ecosystems. For the lowest welfare impact, these should be species which can be more easily bred (most likely those with extant relatives), and

those for which our knowledge of their requirements for rearing, husbandry and reintroduction are good. Only in these sorts of cases, where we have sufficient information and well-chosen candidate species, with a high chance of success, are de-extinction projects likely to be permissible.

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