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Should We Bring Back the Passenger Pigeon? The Ethics of De-Extinction

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ABSTRACT
Recent advances in synthetic biology have made it possible to revive extinct species of animals, a process known as 'de-extinction'. This paper examines two reasons for supporting de-extinction: (1) the potential for de-extinct species to play useful roles in ecosystems; and (2) human valuing of certain de-extinct species. I focus on the particular case of passenger pigeons to argue that the most critical challenge for de-extinction is that it entails significant suffering for sentient individual animals. I also provide reasons to take existence value, or valuing the mere the fact that a species exists, into consideration in debates over de-extinction.

1. Introduction

'De-extinction' refers to the process of reviving previously extinct species, discussed most recently in the context of advances in synthetic biology. In 2012, an organization called Revive and Restore announced plans to pursue de-extinction for the passenger pigeon, which has been extinct since 1914. If the process is successful, scientists could potentially use the technology to bring other species back from extinction, particularly those thought to be important for conservation. Brand (2013), one of the directors of Revive and Restore, sees a confluence of reasons to support de-extinction projects. He claims that the passenger pigeon project, and others like it, have the potential 'To preserve biodiversity, to restore diminished ecosystems, to advance the science of preventing extinctions, and to undo harm that humans have caused in the past'. possible?

This paper explores the specific case of passenger pigeons in order to identify the most critical challenges for de-extinction. Though I primarily focus only on a single species, my conclusions are meant to apply to a wide range of de-extinction candidates.[1] In particular, I examine two main reasons for supporting de-extinction: (1) the potential for de-extinct species to play useful roles in ecosystems; and (2) human valuing of certain de-extinct species. De-extinction for ecosystem development has generally been considered a special case of either reintroduction or managed relocation (e.g. of endangered species), and, as such, has been assessed according to guidelines developed in those contexts (IUCN/SSC, 2016; Jorgensen, 2013; Seddon, Moehrenschlager, & Ewen, 2014). I draw from debates over

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reintroduction and managed relocation in order to identify five challenges for de-extinction. I argue that the most critical challenge for de-extinction of passenger pigeons, which also applies to many other species, is that it seems to entail significant suffering for sentient individual animals. To develop my argument, I consider different ways of thinking about the interests of species and how they compare to the interests of individual members of a species.

With respect to human values, I focus on what are called existence values (valuing the mere fact that a species exists). I review studies of existence value and provide reasons to take existence value into consideration in debates over de-extinction. My conclusions here are measured, since much hangs on empirical facts that have yet to be determined about how people in fact value extinct species. I propose key questions for future research on existence values, especially as they relate to de-extinction.

De-extinction is still permissible on my account, but only if it can overcome the challenges I identify. I conclude by arguing that even if reviving extinct species is impermissible, there are still reasons for developing de-extinction technologies that can be used to help currently existing animals. Before entering into discussion of the critical challenges I see, I will briefly summarize the state of research on de-extinction, and describe some of the most recent proposals for bringing passenger pigeons back from extinction.

2. Developments in De-extinction

Currently, no formerly extinct species have yet been successfully revived. There are no candidates for reintroduction living in captivity, no breeding individuals of any extinct species, nor have the genomes of any extinct species been restored in a way that would permit first real steps toward de-extinction. However, a number of recent scientific developments suggest that each of these milestones will likely be reached within the next decade.

De-extinction technology primarily draws from cloning research developed in the 1990s. For instance, in 2000, scientists used what is called Somatic Cell Nuclear Transfer to produce the first live interspecies birth. This process involved inserting DNA extracted from the skin cells of a gaur into an enucleated oocyte from a domestic cow (Lanza, Cibelli, Diaz, Moraes, & Farin, 2000). However, the offspring, named Noah, only lived for two days (apparently dying from a bacterial infection).

Arguably the first step toward de-extinction occurred in 2003, when scientists successfully cloned a Pyrenean ibex. The mother of the cloned offspring was the last member of this particular subspecies of ibex. Even though the offspring died in minutes, this arguably constituted the first step toward de-extinction for the subspecies (Folch et al., 2009).

The organization Revive and Restore has identified 20 potential candidates for de-extinction, some of whose genomes have already been sequenced. For instance, one of the most prominent proposals has involved woolly mammoths (Macrae, 2011; Nicholls, 2008, 2009; Salsberg, 2000). Though scientists' attitude toward the prospects for woolly mammoths has been one of measured optimism, researchers in Japan have begun modifying previously sequenced mammoth genomes in order to, eventually, attempt de-extinction and reintroduction (Huynen, Millar, & Lambert, 2012; Piña-Aguilar et al., 2009).

One particularly ambitious de-extinction proposal is focused on passenger pigeons. The passenger pigeon is an iconic North American bird that went extinct primarily as a result of human extirpation, largely from hunting, with the last member of the species dying in 1914

(Bucher, 1992; Greenberg, 2014; Halliday, 1980; Johnson, Clayton, Dumbacher, & Fleischer, 2010; McGee, 1910; Neumann, 1985). Researchers have been able to acquire viable DNA from museums and will reportedly finish sequencing the passenger pigeon genome in late 2013 or early 2014 (Hung et al., 2013; Servick, 2013). Once sequencing is complete, researchers have proposed to insert passenger pigeon DNA into an enucleated oocyte of a close-related species, like the band-tailed pigeon or the rock pigeon. The developing embryo would then be implanted into a host. The offspring will not exactly match historic passenger pigeons, since the genome will require some resequencing (due to decay) and will also be intermixed with the genome of the oocyte donor, but an optimistic estimate predicts that the offspring will be 80–90% similar (Bi et al., 2013; Mark, 2013). Over time, with incremental modifications to each generation's genome, the species could more closely approximate the historical passenger pigeon species.

Given the current state of research, we may not see a fully de-extinct species for decades. However, the science raises pressing ethical issues that should be addressed now. The proceeding discussion will take into account the current state of technology as well as future prospects, distant though they still may be.

3. De-extinction for Ecosystem Development

One of the most compelling reasons for taking de-extinction seriously is the possibility that extinct animals could be useful in various ways (Jones, 2014). In May 2016, the International Union for the Conservation of Nature (IUCN/SSC, 2016) released a guidance document for de-extinction acknowledging the potential instrumental value of de-extinct species. For instance, they might come to play important roles in ecosystems, either by fulfilling their historic functions or performing some new function. It is also possible that the roles these species play could benefit human beings. For example, some species might be helpful for keeping pests away from crops. We can think about this general approach to de-extinction as follows:

> *Instrumental de-extinction*: We should bring back those species that can serve some useful function for either human beings or ecosystems.

Instrumental usage of species has been discussed by ethicists in many other contexts, including managed relocation (particularly in response to climate change) and reintroduction of endangered species (Camacho, Doremus, McLachlan, & Minteer, 2010; Ehrenfeld, 2010; Hewitt et al., 2011; Jorgensen, 2013; Palmer & Larson, 2014; Sharma, Bouchard, Ryan, Parker, & Hellmann, 2013). In managed relocation, species are intentionally relocated out of one habitat and into another, sometimes into a place where the species is not native. This may be done for the benefit of the species, because it cannot survive in its native habitat, or for the benefit of an ecosystem, either the species' native habitat or a new target ecosystem. Reintroduction, by contrast, refers to the practice of returning a species to its native habitat. Both managed relocation and reintroduction have been defended in cases where benefits to the target ecosystem and target species outweigh the risks (Armstrong & Seddon, 2008; Hellmann & Pfrender, 2011; Schwartz et al., 2012). De-extinction may likewise be defensible in cases where the introduction of the species would be beneficial and serve to enhance ecosystem functions.

I will discuss five critical challenges to pursuing instrumental de-extinction, and will do so under the assumption that de-extinct species would indeed be reintroduced according to the models of managed relocation and reintroduction for endangered species (as suggested by the IUCN/SSC (2016) guidelines on de-extinction). These five challenges are not meant to be exhaustive but rather point to the most serious ethical issues that advocates of de-extinction must address, if de-extinction is to be morally permissible. These challenges become particularly clear when looking at the case of passenger pigeons, and thus each challenge will be discussed within the specific context of passenger pigeon de-extinction.

The first challenge for de-extinction is that, for many species, the original cause of extinction still exists. Human hunting, for instance, was the primary cause of passenger pigeon extinction. Passenger pigeons were widely perceived to be pests, and would likely be hunted again, unless countermeasures were put in place. Seddon et al.'s (2014) analysis of the feasibility of reviving extinct species suggests that de-extinction projects, if they are successful, would fall under the guidelines set forth by the IUCN. And indeed the IUCN's guidance document on de-extinction recommends that de-extinction projects adhere to the IUCN's guidelines on reintroduction and managed relocation, which state, 'There should generally be strong evidence that the threat(s) that caused any previous extinction have been correctly identified and removed or sufficiently reduced' (IUCN/SSC, 2013, p. 4). Thus, if species are to be brought back under the models of managed relocation and reintroduction, the original cause of extinction must be addressed before de-extinction can proceed.[2] However, if the revived passenger pigeon acts as a pest, like the historic passenger pigeon, then conflicts with human beings seem inevitable, making hunting more likely.

The second challenge for de-extinction is that there is a risk of species becoming invasive. On one definition of a species being 'invasive', a species is invasive if it moves beyond its native or historical range. On another prominent definition, a species is invasive if it has a negative impact on an ecosystem, sometimes even if the ecosystem is within its historic range (Ste-Marie, Nelson, Dabros, & Bonneau, 2011). Passenger pigeons pose a significant threat of being invasive on either definition. The native range of passenger pigeons covers most of the northeastern portion of North America. The northeast is of course much more developed now than it was in the nineteenth century, when the passenger pigeon flourished. Passenger pigeons would thus most likely be reintroduced to a less developed ecosystem outside of its native range, perhaps in the American Northwest. Regardless of where they are returned, however, passenger pigeons are likely to pose a risk to ecosystems. They were known to travel in flocks occasionally numbering in the billions, which could effectively consume entire food sources in a matter of days (Ellsworth & McComb, 2003; McGee, 1910). Even at reduced numbers, passenger pigeons would be in conflict with other animals, including other birds that have come to rely on those food sources and the surrounding habitat (Harrington et al., 2013; Rubenstein, Rubenstein, Sherman, & Gavin, 2006; Seddon et al., 2014).

Third, in order to avoid the problem of invasiveness (and as a contingency plan), we might wish to pursue de-extinction only for species that would be easy to remove (Kumar, 2012). Choosing removable species is a common strategy in managed relocation (IUCN/SSC, 2016; Seddon et al., 2014). However, candidates for de-extinction, like candidates for managed relocation, face an obstacle: the more resilient a species, and the more robust it is to threats, the more difficult it will be to remove. We thus face a dilemma between resiliency and reversibility. Passenger pigeons, for instance, were known for their resiliency, which is part of the reason why they were such a nuisance. If reintroduced, they would likely be difficult to recapture, and may also be difficult to kill (or, as some cities do for the common pigeon, perhaps they could only be managed with poisoned feed). Of course, those currently working to resequence the passenger pigeon genome could put safety measures into the genome, perhaps by making them slower or less capable of flying long distances. But if they were to do this, they would make it more difficult for passenger pigeons to survive on their own, as well as making the de-extinct individuals very different from the historic passenger pigeon.

Fourth, depending on which ecosystem services a de-extinct species is meant to provide, bringing back only a single species could be ineffective. For instance, in the context of managed relocation, Sandler (2013) has argued that a single-species focus is unlikely to be an effective conservation strategy, given the enormous challenges to ecosystem sustainability. It is true that there are cases where reintroduction of a single 'keystone' species has had significant side effects on the ecosystem as a whole. For example, the introduction of gray wolves to Yellowstone National Park reduced the number of elk, which in turn increased plant species affected by elk, including aspen, cottonwood, and willow (Ripple & Beschta, 2012). Passenger pigeons could have similar effects (e.g. they were responsible for dispersing many nut-bearing trees; Bucher, 1992). But these cases are rare and the effects remain limited; keystone species do not restore ecosystems on their own. Passenger pigeons would thus need to be brought back with a cluster of other species, especially when attempting to reconstruct an entire ecosystem. However, doing so would significantly compound all the risks of reintroduction already mentioned.

The fifth and most challenging moral issue raised by de-extinction is that it seems to entail significant suffering for sentient individual animals. This is true for de-extinction of any sort, not just instrumental de-extinction. If de-extinction is successful, the individuals will eventually die, but the species will persist through future generations of offspring. This in fact defines a successful de-extinction. However, this raises the question of who benefits from this process (aside from human beings reviving the species). Will the interests of individual members of a species be met in the process of reviving that species, or will their interests need to be sacrificed in order to successfully achieve de-extinction? Can we even make sense of species having interests in a way that justifies potentially opposing the interests of individuals?

It is often assumed in discussions of de-extinction that extinct species, as such, will benefit from de-extinction. This is problematic, however, because it is not clear whether species, qua species, have morally relevant interests. Possessing morally relevant interests is typically thought to differentiate individual members of a species from the species as a whole.[3] For instance, it is often argued that individual sentient animals have morally relevant interests because they can experience pain and can suffer. Given the aversive nature of these states, sentient animals have an interest in avoiding them, and human agents, therefore, have a duty not to inflict pain or suffering on sentient animals. 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 benefited or harmed in the same way individual animals can be benefited or harmed. As Sandler (2014) has argued, 'gray wolves, black rhinoceroses, and human beings can be harmed or wronged, whereas *Canis lupis*, *Diceros bicornis*, and *Homo sapiens* cannot be' (p. 355).

Some ethicists embrace the fact that the interests of species and individuals are morally different, but they nonetheless maintain that acts can be done for the benefit of the species, as a whole. Holmes Rolston, for instance, says, 'The species *is* a bigger event than the individual with its interests or sentience. Events can be good for the well-being of the species, considered collectively, although they are harmful if considered as distributed to individuals' (Rolston (1994); also see the essays in Rolston (1986)). The main problem with this idea, as just explained, is that it is not clear whether 'well-being' can be meaningfully attributed to a species. Rather, as other ethicists have argued, talking about the well-being of a species is just an indirect way of referring to the aggregate well-being of individual members of the species (both present and future; Aldred, 1994; Palmer 2009, 2011).

For instance, suppose passenger pigeons are introduced to an ecosystem where they are constantly under threat from predation, which produces enormous amounts of suffering, but the species nonetheless continues to survive. In such a case, separating the interests of the species from the interests of its individual members allows for the species' interests to be met (at least the interest to continue existing, assuming it exists) even if *every* individual experiences significant suffering. This seems extremely implausible. It is also deeply morally problematic. Justifying de-extinction on the grounds that it meets species' interests in this way should certainly be seen as illegitimate.

Even if we reject the Rolstonian line of thought, there is still another way that de-extinction can entail significant suffering for individuals. Consider a justification that Stewart Brand has offered for de-extinction, specifically in the case of the Pyrenean Ibex (bucardos), 'We're going to go through some suffering, because you try a lot of times, and you get ones that don't take. On the other hand, if you can bring bucardos back, then how many would get to live that would not have gotten to live?' (Rich, 2014). Here, Brand is invoking a sort of utilitarian argument. We could perhaps justify initial suffering, he seems to think, if it paves the way for many future lives.

There are two problems with this claim. First, the utilitarian justification in itself is quite controversial. It certainly wouldn't be in the interest of the initial individuals to be made to suffer. Many ethicists would be reluctant to accept that the possible existence of future animal lives could justify intense suffering for the first individuals. At the very least, Brand would need to verify that the initial individuals could be guaranteed a certain level of well-being—in common parlance, a 'life worth living'. Second, Brand's statement assumes that the lives of later individuals are worth living, and not also full of suffering. Even if we accept a basic utilitarian justification for de-extinction, we must ensure that the lives of future individuals can indeed justify any initial suffering. If all members of a species suffer significantly—such that their lives are not worth living—then the utilitarian justification fails.

These considerations are important because the current state of de-extinction technology provides good reasons to think the lives of de-extinct individuals will indeed be full of suffering. For instance, there are numerous welfare issues involved with cloning and related technologies. The rate of aborted fetuses (or unviable eggs) is quite high, many offspring die shortly after birth, and those who manage to live to adulthood possess various deformities and suffer from a range of health issues (Campbell, McWhir, Ritchie, & Wilmut, 1996; Hajian et al., 2011; Wilmut, Schnieke, McWhir, Kind, & Campbell, 1997; Young, Sinclair, & Wilmut, 1998). Though things are improving, somatic cell nuclear transfer between species continues to be problematic, with only 1–6% of such procedures leading to successful cloning of the targeted species (Hwang et al., 2013; Loi, Modlinski, & Ptak, 2011).

This problem is particularly acute in the case of passenger pigeons, where there is some evidence that there would be significant suffering even for healthy adults. In the late nineteenth century, when the population of passenger pigeons reached a few thousand individuals, they simply ceased reproducing. The exact explanation for this is unknown, but it is suspected that passenger pigeons require a very large minimum colony size in order to reproduce successfully (Halliday, 1980; Hung et al., 2014; Neumann, 1985). The reason for this is also unknown, but one common suspicion when such reproductive issues are observed is that there is an underlying welfare problem. This could take different forms: perhaps passenger pigeons could not find suitable mates within their reduced flocks; perhaps there was some degree of sexual frustration, given the reduced variability in mates; or perhaps there were other stressors, like hunting. Whatever the exact problem, these reproductive issues with passenger pigeons give us reason to think that the initial reintroduction would involve significant suffering, perhaps until colony sizes reach thousands of individuals.

In summary, advocates for de-extinction need to provide some reason to think that the interests of individual sentient organisms will be met in the process of de-extinction. At the very least, they need to present evidence that the 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. And as I have suggested, the current state of the technology does indeed entail significant suffering for most, if not all, individuals brought into existence. Thus, even if the first four challenges I identified could be resolved, 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.

4. De-extinction for Human Values

In this section, I turn to issues raised by human values and species' usefulness to human beings. As various commentators have noted, one of the main factors driving recent proposals for de-extinction is their 'coolness' (Rich, 2014; Sherkow & Greely, 2013). Though 'coolness' might explain some of the interest in de-extinction, it misrepresents the psychology of valuing species. Here, I review research on existence value in order to provide a better explanation for why people have taken an interest in de-extinction. I also provide reasons to take people's existence values into consideration when constructing policies concerning de-extinction. I conclude by identifying key research questions for future studies of existence value.

We can think about the prospect of reviving extinct species according to human values as follows:

> *Value-driven de-extinction*: Highly valued species, or species that people think they would value, if the species existed in their lifetimes, should be brought back from extinction.

The philosophical literature on the value of species tends to focus on intrinsic value, which is typically understood to mean 'non-instrumental value', or the value that a species has apart from how it is used or experienced by human beings (McShane, 2007; O'Neill, Holland, & Light, 2008). That species have intrinsic value is typically taken to be a metaphysical thesis: a claim about the nature of the world. However, I will focus on what I take to be the psychological equivalent of attributing intrinsic value to species. This is called *existence value*.

Existence value is the value people attribute to a species merely for its existence. When studied by psychologists and economists, this is usually understood as the value attributed to a species regardless of how the species might be used (what is called 'nonuse value') and regardless of whether people ever have or ever will encounter the species (unless they encounter it in magazines, television, etc.—what is called 'indirect use value'; Aldred, 1994; Davidson, 2013). Most of the research on existence value focuses not on extinct species but on what people think about endangered species and ecosystems. However, research on existence value for endangered species gives us at least some idea of what people's values might be with respect to de-extinction.

Research on existence value goes back to the 1960s, though most in-depth studies weren't conducted until the 1980s and 1990s (Bowker & Stroll, 1980; Krutilla, 1967). The primary method for assessing existence value is to ask people how much they would pay to preserve a species (what is called 'willingness-to-pay' or 'contingent valuation'). The preservation strategies presented to participants can be relatively minimal (e.g. changing a species' status from 'threatened' to 'endangered') or much more ambitious and costly (e.g. a breeding program intended to increase the population size). Calculating species' existence value in this way can help prioritize conservation goals and allocate resources accordingly.

As of 2009, existence values had been calculated for over 40 endangered species (Richardson & Loomis, 2009).[4] However, existence value of bird species has been relatively ignored, and no pigeon species have been assessed.[5] I will describe a well-known study conducted by Kotchen and Reiling (2000) to illustrate how people's values might determine their support for de-extinction proposals.

Kotchen and Reiling conducted a study in Maine in order to assess people's willingness to protect either peregrine falcons or sturgeon, both of which were common in Maine and were endangered at the time of study (1997). Participants received background information on one of the two species (e.g. range size and basic biological statistics) as well as a proposed recovery plan. They were then asked if they would support the recovery plan and how much they would pay in increased taxes if the proposed recovery plan were funded by taxpayer money (with specified amounts ranging from $2 to $50 for peregrines and $1 to $35 for sturgeon). Follow-up questions were asked to further probe the reasoning behind people's responses.

Among those who agreed to pay, the most popular explanation for their response (among a set of predetermined possible explanations) was that 'all endangered species in Maine have a right to exist'. The rest of the explanations, in order, were that participants would enjoy knowing that the species existed: even if the species was never encountered by other human beings; because future generations can enjoy the species; because others can enjoy the species; because they personally may want to see the species in the future. These responses indicate that sturgeon and peregrines were valued because of their mere existence, and not for their use by humans or the pleasurable experiences they might provide.[6] This is what one would expect if people generally value the existence of species.

If human beings value the mere existence of species, as indicated by this experiment, then they will also likely value (and advocate for) the revival of extinct species. Even someone who knows nothing about passenger pigeons, for instance, may yet advocate for their de-extinction. This would not be merely for its 'coolness' but because of a general preference for the existence of species. Of course, much more research needs to be done before one can claim that this is indeed a feature of our psychological profiles, but the sort of phenomenon observed by Kotchen and Reiling is highly suggestive.

The usefulness of existence value has its critics, however. Even if a general preference for species existence is part of our psychological profiles, we might think that it has no place in determining policies concerning endangered or extinct species. For instance, in the context of managed relocation, Sandler (2010)argues that existence value should not be taken into consideration because people's preferences, in regards to species, are (1) too variable, (2) usually in conflict with others' preferences, and (3) unrelated to actual species value (e.g. its actual value for an ecosystem).

Though Sandler's evaluation of the nature of human preferences seems mostly right, his conclusion to therefore dismiss existence value is premature. Given the nature of existence value, as described above, it is not unreasonable to expect strong support for de-extinction. Moreover, some species—perhaps the passenger pigeon—are likely to be very popular, even among those with divergent preferences regarding species. Insofar as the public will influence the success of reintroduction as well as funding available for de-extinction projects, their values regarding species must be taken into account.

Sandler is right, however, that people's preferences are likely to conflict enough to make them unhelpful guides. The main problem is that species some would prefer to exist will necessarily conflict with the existence of species that others will prefer. These conflicts may also cause significant suffering for individual animals. For instance, passenger pigeons, as discussed above, could consume resources that other highly valued species rely on to survive. The case of woolly mammoths, with respect to human preferences and values, is also instructive. Some have proposed pursuing de-extinction for mammoths in order to provide diversity to otherwise sparse ecosystems (e.g. the tundra). However, it is at least conceivable that some people value the existence of sparse ecosystems. Or, at the very least, they might prefer sparse ecosystems to what mammoths provide.

These potential conflicts should not lead us to ignore existence values, however. It seems instead that these potential conflicts further demonstrate why existence values for species must factor into policies regulating de-extinction. Knowing which species people value and why would allow scientists and policy makers to (1) avoid conflicts between different species and (2) better satisfy people's preferences in accordance with their values. Both of these factors will determine the success and feasibility of de-extinction projects.

In summary, 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. The focus for de-extinction advocates, as well as psychologists and economists working on existence value, should be to begin assessing people's values with respect to extinct species. To further develop research on existence value, I will briefly sketch some possible questions for future studies.

First, researchers should investigate the strength of the relationship between paying to preserve a species and *valuing* that species. Participants in Kotchen and Reiling's study seemed to indicate that they valued species' existence, as such, because they justified their responses in reference to the rights of all species, instead of in reference to how they personally might use species. However, this may not generalize to de-extinct species. Current funding for passenger pigeon de-extinction, for instance, does indicate a 'willingness to pay', but without more research it is not clear whether this is due to a more fundamental valuing of the species.

Second, we must determine whether people value particular forms of species' existence. Instead of valuing mere existence for species, people may only value species within specific contexts. For instance, people may only value the existence of passenger pigeons if they are returned to their original habitat. Sandler (2013)argues, in the context of managed relocation, that a species' value is often tied to its ecological context and location. However, what context-specific valuing entails for de-extinction is not entirely clear. There arguably is no 'ecological context' for a long extinct species. Some species may even be valued for their current role in museums! Many studies of existence value, including Kotchen and Reiling's, assess people's opinions about the preservation of species within their native habitat, or at least within an area in which people understood their particular form of existence. Their responses may change, however, if the preservation of the species would require relocation, or if the context was left unspecified.[7]

5. Concluding Thoughts: Pursuing the Technology of De-Extinction

To return briefly to the topic of de-extinction for ecosystem development, a conclusion one might take from my arguments is that de-extinction technology should not be pursued at all. However, though my comments thus far have been largely critical, they are meant not to discourage de-extinction but to enrich the debate. I reject the view, advocated by some, that de-extinction technology should not proceed until a plan is in place for reintroduction. Jorgensen (2013), for example, says, 'Scientific background studies, including the assessment of the socioeconomic aspects of the project, should be undertaken before the technical work on re-creating the species. If the species has nowhere to go, de-extinction should not move forward' (p. 719). I also reject the view that there is no real ethical reason for developing de-extinction technology. For instance, Sandler (2014)recent analysis of de-extinction concludes, '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' (p. 359).

De-extinction technology has the potential to provide a number of benefits to both humans and animals, and much of the technology can be developed without causing harm to any sentient beings. All of the research on passenger pigeons, for instance, has been pursued without any real proposals for where the species would go if de-extinction was successful. Though this might be somewhat imprudent, it does not seem to raise any serious ethical issues. No individuals have been harmed, nor are researchers nearing the stage where individuals might be brought into existence. Passenger pigeons were chosen partly because of feasibility: their genome is relatively easy to sequence. The difficult work that still needs to be done is modifying the passenger pigeon genome. This is currently the greatest technological challenge for researchers attempting de-extinction, and it is also a good reason why de-extinction should move forward, even without a legitimate plan for reintroduction.

Besides being a substantial leap forward in technology, many of the technologies developed for de-extinction could also be used for other conservation projects—ones that do not raise as many difficult ethical issues. There are now a number of ways in which genome sequencing is being used for conservation purposes (Kumar, 2012; Primmer, 2009; Redford, Adams, & Mace, 2013; Thomas et al., 2013). To take a simple example, an animal that has reached its thermoregulatory threshold because of climate change, and so has become endangered, could be genetically modified so that it can withstand warmer temperatures (Whitehead, 2012). The technology being developed for de-extinction could be helpful in such a case (though of course there are some who object in principle to the genetic modification of living organisms; Ormandy, Dale, & Griffin, 2011; Verhoog, 2003).

Many technologies in conservation genetics (as applied to endangered species) do raise many of the same questions as de-extinction, especially when talking about the benefits to future members of the species (as opposed to benefits for the species as a whole). But these technologies are also attempting to solve problems that *currently existing* sentient animals are facing, and in so doing improve their well-being. Unlike with de-extinction, this offers good grounds for thinking that the technology would benefit individual animals.

Notes

1. My arguments will be primarily aimed at de-extinction of sentient individuals. Some of my conclusions will have implications for non-sentient organisms, but the most critical challenges I identify are problematic solely for de-extinction of sentient individuals.
2. Jorgensen (2013), who looks to the history of reintroduction to inform management of de-extinction, argues, 'at a minimum, the species should be targeted for de-extinction only if the original causes of extinction are removed and the habitat requirements of the species are satisfied' (p. 719).
3. I take Sandler and Crane (2006) to have effectively demonstrated that even if we grant that species have interests, it is still difficult to see why those interests would be morally relevant.
4. Recently, a number of marine species have also been assessed. See Wallmo and Lew (2011, 2012).
5. Most studies have focused on the bald eagle. Other bird species that have been studied include the red-cockaded woodpecker and various owl species. See Richardson and Loomis (2009).
6. For further statistical analysis of the results of this study, see Aldrich, Grimsrud, Thacher, and Kotchen (2007).
7. For a critique of existence value based on its lack of context-sensitivity, see Sagoff (1998).

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References

Aldred, J. (1994). Existence value, welfare and altruism. *Environmental Values, 3*, 381–402.

Aldrich, G. A., Grimsrud, K. M., Thacher, J. A., & Kotchen, M. J. (2007). Relating environmental attitudes and contingent values: How robust are methods for identifying preference heterogeneity? *Environmental and Resource Economics, 37*, 757–775.

Armstrong, D. P., & Seddon, P. J. (2008). Directions in reintroduction biology. *Trends in Ecology & Evolution, 23*, 20–25.

Bi, K., Linderoth, T., Vanderpool, D., Good, J. M., Nielsen, R., & Moritz, C. (2013). Unlocking the vault: Next-generation museum population genomics. *Molecular Ecology, 22*, 6018–6032.

Bowker, J. M., & Stroll, J. R. (1980). Use of dichotomous choice non-market methods to value the whooping crane resource. *American Journal of Agricultural Economics, 70*, 372–381.

Brand S. (2013, March 11). *Opinion: The case for reviving species*. *National Geographic News*. Retrieved from http://news.nationalgeographic.com/news/2013/03/130311-deextinction-reviving-extinct-species-opinion-animals-science/

Bucher, E. H. (1992). The causes of extinction of the passenger pigeon. In D. M. Power (Ed.), *Current Ornithology* (pp. 1–36). New York, NY: Plenum Press.

Camacho, A. E., Doremus, H., McLachlan, J. S., & Minteer, B. A. (2010). Reassessing conservation goals in a changing climate. *Issues in Science and Technology, 26*, 21–26.

Campbell, K. H., McWhir, J., Ritchie, W. A., & Wilmut, I. (1996). Sheep cloned by nuclear transfer from a cultured cell line. *Nature, 380*, 64–66.

Davidson, M. D. (2013). On the relation between ecosystem services, intrinsic value, existence value and economic valuation. *Ecological Economics, 95*, 171–177.

Ehrenfeld, J. G. (2010). Ecosystem consequences of biological invasions. *Annual Review of Ecology, Evolution, and Systematics, 41*, 59–80.

Ellsworth, J. W., & McComb, B. C. (2003). Potential effects of passenger pigeon flocks on the structure and composition of presettlement forests of Eastern North America. *Conservation Biology, 17*, 1548–1558.

Folch, J., Cocero, M. J., Chesné, P., Alabart, J. L., Domínguez, V., Cognié, Y., & Roche, A. (2009). First birth of an animal from an extinct subspecies (*Capra pyrenaica pyrenaica*) by cloning. *Theriogenology, 71*, 1026–1034.

Greenberg, J. (2014). *A feathered river across the sky: The passenger pigeon's flight to extinction*. New York, NY: Bloomsbury Press.

Hajian, M., Hosseini, S. M., Forouzanfar, M., Abedi, P., Ostadhosseini, S., Hosseini, L., & Moulavi, F. (2011). "Conservation cloning" of vulnerable Esfahan mouflon (*Ovis orientalis isphahanica*): *in vitro* and *in vivo* studies. *European Journal of Wildlife Research, 57*, 959–969.

Halliday, T. R. (1980). The extinction of the passenger pigeon *ectopistes migratorius* and its relevance to contemporary conservation. *Biological Conservation, 17*, 157–162.

Harrington, L. A., Moehrenschlager, A., Gelling, M., Atkinson, R. P., Hughes, J., & Macdonald, D. W. (2013). Conflicting and complementary ethics of animal welfare considerations in reintroductions. *Conservation Biology, 27*, 486–500.

Hellmann, J. J., & Pfrender, M. E. (2011). Future human intervention in ecosystems and the critical role for evolutionary Biology. *Conservation Biology, 25*, 1143–1147.

Hewitt, N., Klenk, N., Smith, A. L., Bazely, D. R., Yan, N., Wood, S., MacLellan, J. I. (2011). Taking stock of the assisted migration debate. *Biological Conservation, 144*, 2560–2572.

Hung, C., Lin, R., Chu, J., Yeh, C., Yao, C., & Li, S. (2013). The de novo assembly of mitochondrial genomes of the extinct passenger pigeon (*Ectopistes migratorius*) with next generation sequencing. *PLoS ONE, 8*, e56301.

Hung, C., Shaner, P. L., Zink, R. M., Liu, W., Chu, T., Huang, W., & Li, S. (2014). Drastic population fluctuations explain the rapid extinction of the passenger pigeon. *Proceedings of the National Academy of Sciences, 111*, 10636–10641.

Huynen, L., Millar, C. D., & Lambert, D. M. (2012). Resurrecting ancient animal genomes: The extinct moa and more. *BioEssays, 34*, 661–669.

Hwang, I., Jeong, Y. W., Kim, J. J., Lee, H. J., Kang, M., Park, K. B., Park, Jung Hwan (2013). Successful cloning of coyotes through interspecies somatic cell nuclear transfer using domestic dog oocytes. *Reproduction, Fertility, and Development, 25*, 1142–1148.

IUCN/SSC. (2013). *Guidelines for reintroductions and other conservation translocations* (Version 1.0. Gland). Switzerland: IUCN Species Survival Commission.

IUCN/SSC. (2016). *Guiding principles on creating proxies of extinct species* (Version 1.0. Gland). Switzerland: IUCN Species Survival Commission.

Johnson, K. P., Clayton, D. H., Dumbacher, J. P., & Fleischer, R. C. (2010). The flight of the passenger pigeon: Phylogenetics and biogeographic history of an extinct species. *Molecular Phylogenetics and Evolution, 57*, 455–458.

Jones, K. E. (2014). From dinosaurs to dodos: Who could and should we de-extinct? *Frontiers of Biogeography, 6*, 20–24.

Jorgensen, D. (2013). Reintroduction and de-extinction. *BioScience, 63*, 719–720.

Kotchen, M. J., & Reiling, S. D. (2000). Environmental attitudes, motivations, and contingent valuation of nonuse values: A case study involving endangered species. *Ecological Economics, 32*, 93–107.

Krutilla, J. (1967). Conservation reconsidered. *American Economic Review, 57*, 777–786.

Kumar, S. (2012). Extinction need not be forever. *Nature, 492*, 9.

Lanza, R. P., Cibelli, J. B., Diaz, F., Moraes, C. T., & Farin, P. W. (2000). Cloning of an endangered species (*Bos gaurus*) using interspecies nuclear transfer. *Cloning, 2*, 79–90.

Loi, P., Modlinski, J. A., & Ptak, G. (2011). Interspecies somatic cell nuclear transfer: A salvage tool seeking first aid. *Theriogenology, 76*, 217–228.

Macrae, F. (2011, February 4). *Will the woolly mammoth be lumbering back? Japanese scientists 'to resurrect extinct giant from frozen DNA*. Mail Online. Retrieved from http://www.dailymail.co.uk/sciencetech/article-1348000/Woolly-mammoth-Japanese-scientists-resurrect-extinct-giant-fozen-DNA.html

Mark J. (2013, September 6). *De-extinction won't make us better conservationists!* Salon. Retrieved from http://www.salon.com/2013/09/06/de_extinction_wont_make_us_better_conservationists_partner/

McGee, W. J. (1910). Notes on the passenger pigeon. *Science, 32*, 958–964.

McShane, K. (2007). Why environmental ethics shouldn't give up on intrinsic value. *Environmental Ethics, 29*, 43–61.

Neumann, T. W. (1985). Human-wildlife competition and the passenger pigeon: Population growth from system destabilization. *Human Ecology, 13*, 389–410.

Nicholls, H. (2008). Darwin 200: Let's make a mammoth. *Nature, 456*, 310–314.
Nicholls, H. (2009). Ten extinct beasts that could walk Earth again. *New Scientist, 201*, 24–28.
O'Neill, J., Holland, A., & Light, A. (2008). *Environmental values*. New York, NY: Routledge.
Ormandy, E. H., Dale, J., & Griffin, G. (2011). Genetic engineering of animals: Ethical issues, including welfare concerns. *Canadian Veterinary Journal, 52*, 544–550.
Palmer, C. (2009). Harms to species? Species, ethics and climate change: The case of the polar bear. *Notre Dame Journal of Law, Ethics and Public Policy, 23*, 587–603.
Palmer, C. (2011). Does nature matter? The place of the nonhuman in the ethics of climate change. In D. G. Arnold (Ed.), *The Ethics of Global Climate Change* (pp. 272–291). Cambridge: Cambridge University Press.
Palmer, C., & Larson, B. (2014). Should we move the whitebark pine? Assisted migration, ethics and global environmental change. *Environmental Values, 23*, 641–662.
Piña-Aguilar, R. E., Lopez-Saucedo, J., Sheffield, R., Ruiz-Galaz, L. I., Barroso-Padilla, J. de-J., & Gutiérrez-Gutiérrez, A. (2009). Revival of extinct species using nuclear transfer: Hope for the mammoth, true for the Pyrenean Ibex, but is it time for "conservation cloning"? *Cloning and Stem Cells, 11*, 341–346.
Primmer, C. R. (2009). From conservation genetics to conservation genomics. *Annals of the New York Academy of Sciences, 1162*, 357–368.
Redford, K. H., Adams, W., & Mace, G. M. (2013). Synthetic biology and conservation of nature: Wicked problems and wicked solutions. *PLoS Biology, 11*, e1001530.
Rich, N. (2014, February 27). The mammoth cometh. *New York Times Magazine*. Retrieved from http://www.nytimes.com/2014/03/02/magazine/the-mammoth-cometh.html
Richardson, L., & Loomis, J. (2009). The total economic value of threatened, endangered and rare species: An updated meta-analysis. *Ecological Economics, 68*, 1535–1548.
Ripple, W. J., & Beschta, R. L. (2012). Trophic cascades in yellowstone: The first 15years after wolf reintroduction. *Biological Conservation, 145*, 205–213.
Rolston, H. III (1986). *Philosophy gone wild: Essays in environmental ethics*. Amherst, NY: Prometheus.
Rolston, H., III (1994). Value in nature and the nature of value. In R. Attfield & A. Belsey (Eds.), *Philosophy and the Natural Environment* (pp. 13–30). Cambridge: Cambridge University Press.
Rubenstein, D. R., Rubenstein, D. I., Sherman, P. W., & Gavin, T. A. (2006). Pleistocene Park: Does re-wilding North America represent sound conservation for the 21st century? *Biological Conservation, 132*, 232–238.
Sagoff, M. (1998). Existence value and intrinsic value. *Ecological Econimics, 24*, 163–168.
Salsberg, C. A. (2000). Resurrecting the woolly mammoth: Science, law, ethics, politics and religion. *Stanford Technology Law Review, 1*, 1–30.
Sandler, R. (2010). The value of species and the ethical foundations of assisted colonization. *Conservation Biology, 24*, 424–431.
Sandler, R. (2013). Climate change and ecosystem management. *Ethics, Policy and Environment, 16*, 1–15.
Sandler, R. (2014). The ethics of reviving long extinct species. *Conservation Biology, 28*, 354–360.
Sandler, R., & Crane, J. (2006). On the moral considerability of *Homo sapiens* and other species. *Environmental Values, 15*, 69–84.
Schwartz, M., Hellmann, J., McLachlan, J., Sax, D., Borevitz, J., Brennan, J., & Safford, H. (2012). Managed relocation: Integrating the scientific, regulatory and ethical challenges. *BioScience, 62*, 732–743.
Seddon, P. J., Moehrenschlager, A., & Ewen, J. (2014). Reintroducing resurrected species: Selecting deextinction candidates. *Trends in Ecology & Evolution, 29*, 140–147.
Servick, K. (2013, March 15). The plan to bring the iconic passenger pigeon back from extinction. *Wired Science*. Retrieved from http://www.wired.com/wiredscience/2013/03/passenger-pigeon-de-extinction/all/
Sharma, A., Bouchard, F., Ryan, S., Parker, D., & Hellmann, J. (2013). Species are the building blocks of ecosystem services and environmental sustainability. *Ethics, Policy and Environment, 16*, 29–32.
Sherkow, J. S., & Greely, H. T. (2013). What if extinction is not forever? *Science, 340*, 32–33.
Ste-Marie, C., Nelson, E. A., Dabros, A., & Bonneau, M.-E. (2011). Assisted migration: Introduction to a multifaceted concept. *The Forestry Chronicle, 87*, 724–730.
Thomas, M. A., Roemer, G. W., Donlan, C. J., Dickson, B. G., Matocq, M., & Malaney, J. (2013September 26). Ecology: Gene tweaking for conservation. *Nature, 501*, 485–486.

Verhoog, H. (2003). Naturalness and the genetic modification of animals. *Trends in Biotechnology, 21*, 294–297.

Wallmo, K., & Lew, D. K. (2011). Valuing improvements to threatened and endangered marine species: An application of stated preference choice experiments. *Journal of Environmental Management, 92*, 1793–1801.

Wallmo, K., & Lew, D. K. (2012). Public willingness to pay for recovering and downlisting threatened and endangered marine species. *Conservation Biology, 26*, 830–839.

Whitehead, A. (2012). Comparative genomics in ecological physiology: Toward a more nuanced understanding of acclimation and adaptation. *Journal of Experimental Biology, 215*, 884–891.

Wilmut, I., Schnieke, A. E., McWhir, J., Kind, A. J., & Campbell, K. H. (1997). Viable offspring derived from fetal and adult mammalian cells. *Nature, 385*, 810–813.

Young, L. E., Sinclair, K. D., & Wilmut, I. (1998). Large offspring syndrome in cattle and sheep. *Reviews of Reproduction, 3*, 155–163.