

Restitution, Restoration, and Reviving Extinct Species

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ABSTRACT: “De-extinction” projects propose to re-create or “resurrect” extinct species. Perhaps the most common justification offered for these projects is that humans have an obligation to make restitution to species we have eradicated. This essay examines three versions of this argument for de-extinction—one individualistic, one concerned with species, and one that emphasizes ecological restoration—and contends that all three fail to provide a compelling case for species revival. A general critique of de-extinction is then sketched, one that highlights how it can both facilitate inattentiveness to biological and ecological boundaries, and foster a managerial mentality towards the natural world.

Environmental groups often warn that “extinction is forever,” yet recent advances in genetic science may prove this warning wrong. In 1999, more than sixty years after the last living thylacine died, Australian researchers announced plans to reconstruct the animal’s genome, synthesize its DNA, and use cloning techniques to resurrect the species.¹ The “Revive and Restore” project is on a similar mission, and is presently sequencing the genome of the passenger pigeon in the hope that the extinct bird can be re-animated through a series of genetic and reproductive manipulations of one of its extant relatives.² Already, in 2003, scientists cloned a type of wild goat called a “bucardo” that had gone extinct several years before. Although the cloned bucardo lived only for a few minutes, it was a landmark scientific achievement: for the first time ever, a member of an extinct species had been brought back to life.³

Such “de-extinction” projects are complicated, costly, and tremendously difficult. They also raise a host of challenging philosophical and ethical questions, the most basic of which is whether or not they ought to be pursued at all. Unfortunately, academic writing on this subject is sparse and tends not to address problems of fundamental ethical justification. Nevertheless, de-extinction advocates have suggested an underlying rationale for their efforts. Encapsulating the views of many de-extinctionists, Jacob Sherkow and Henry Greely write that “[j]ustice is a

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viscerally attractive argument for de-extinction, at least for species that humans drove to extinction: We killed them. We have the power to revive them. We have a duty to do so.”⁴

Hence the general consensus among its practitioners and proponents seems to be that de-extinction is not only morally acceptable, but possibly morally required, as a form of “restitution” for the past wrongs of anthropogenic extinction. But can attempts to revive species really be justified in this way? My primary goal in this paper is to venture an answer to this question. To do so, I identify and analyze, in turn, three possible versions of this restitutive defense of de-extinction projects, and contend that, ultimately, all three versions fail to provide a compelling case for species revival. I then close the essay with a discussion of how the ideal of resurrecting species can both facilitate continued human inattentiveness to biological and ecological boundaries, and foster a problematic managerial mentality towards the natural world.

Restitution to Individuals?

The conviction that there is a requirement to make amends for the wrongs one commits is compatible with a variety of positions in both human and environmental ethics. The underlying positions of de-extinction advocates, however, tend to be relatively unclear, since they usually do not specify to what or to whom amends are intended to be made by resurrecting a species. Although it is almost never described as a matter of making amends to humans, this still leaves open several broad possibilities within non-anthropocentric ethical frameworks. Should de-extinction be regarded as a way of compensating individual organisms, or is it a way of righting wrongs done to species? Is it perhaps instead a matter of restoring the ecosystems of which these organisms and species were once a part?

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As a way of navigating this initial difficulty, we might begin by observing that, in the eco-philosophical literature, one of the most extensive treatments of the idea of restitution is found in Paul Taylor's *Respect for Nature*.⁵ As Taylor explains it, the rule of restitutive justice "imposes the duty to restore the balance of justice between a moral agent and a moral subject when the subject has been wronged by the agent." Of course, Taylor recognizes that what counts as restitution will vary from case to case, but he does develop some "middle-range principles" that outline what he thinks our restitutive practices should entail.⁶ Accordingly, he claims that in situations where organisms have been harmed but not killed, restitution demands "returning those organisms to a position where they can pursue their good as well as they did before the injustice was done to them."⁷ If, on the other hand, the harm to an organism involved its death, such that nothing can be done to help it resume the pursuit of its good, then Taylor contends that "the agent owes some form of compensation to the species-population and/or the life community of which the organism was a member." This compensation would be, he says, "a natural extension of respect from the individual to its genetic relatives and ecological associates."⁸

For present purposes, the most important thing to note here is that Taylor's characterization of the rule of restitution aligns with its usage in conventional ethical and legal contexts, where it is typically taken to require making amends either directly to the individual entities one has wronged, or to other individuals that have suffered losses as a result of that wrongdoing.⁹ To be sure, on Taylor's bio-centric telling, the range of individuals to whom amends might need to be made includes not only organisms that were themselves harmed by humans, but also their "genetic relatives" and "ecological associates." But despite this apparent comprehensiveness, there are serious obstacles to utilizing this individualistic account of restitution in defense of de-extinction.

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The over-arching problem, in short, is that in cases of anthropogenic extinction there are actually very few individuals to whom restitution might properly be directed. Since the wrong done to organisms in these cases involves their deaths, humans cannot, in any ordinary sense, make restitution to the same individuals that were harmed. Likewise, it is hard to see how de-extinction projects could compensate the genetic relatives of organisms killed since, even if we could make sense of the idea that reviving the dead compensates the living, the nature of extinction is such that any living relatives of the harmed individuals will so far removed that they form a different taxonomic group. Trying to frame de-extinction as restitution to an organism's ecological associates has similar problems: given that many of the species slated for revival have been extinct for decades if not centuries, the actual individuals that were their ecological associates will tend to be rather distant, if indeed any are still alive at all.¹⁰

Now, de-extinction is surely no ordinary process, and it might be argued that it is simply a novel way of making amends to individuals that humans have wronged, a technologically innovative means of, as Taylor put it, "returning...organisms to a position where they can pursue their good..."¹¹ In the majority of cases, however, whatever organisms researchers would revive would not be genetically identical to any of those that were killed; in fact, they are likely even to be genetically dissimilar from the species originally driven to extinction.¹² But even if a proposed de-extinction project involved cloning, simply producing a living organism that is genetically identical to one that is dead does not mean that one has thereby revived the same individual. This is especially evident with sentient beings, which are regularly taken to be unique, even when they are genetically the same.¹³

Whatever else one might want to say about them, therefore, species revival projects do not enable individual organisms that humans previously harmed to resume the pursuit of their

goods. Nevertheless, that individualistic arguments come up short in this way does not mean that these projects cannot possibly represent a form of restitution. It does indicate, though, that they are probably not intended to make restitution to individual organisms *per se*. They are, rather, probably best understood as attempts to reestablish *species*.

Restitution to Species?

The idea that species are morally significant sits squarely on one side of one of the major intellectual fault lines running through contemporary environmental thought. It is true, however, that many ecologists and natural resource professionals downplay the moral worth of individual organisms in favor of the position that sees value in and the prioritizes the preservation of the biological kinds that those individuals represent.¹⁴ As Michael Soulé has explained, conservation biologists and scientific ecologists generally adhere to the norm that “diversity is good,”¹⁵ and hold that “the ethical imperative to conserve species diversity is distinct from any societal norms about the value or the welfare of individual animals or plants.”¹⁶

As one might expect, such an ethically holistic orientation to species preservation is fairly common among de-extinction advocates.¹⁷ From this perspective, the moral focus of revival projects will not be on making restitution to particular organisms, but on re-animating organisms as a way of recompensing the forms of life they embody. Yet as initially appealing as this line of thought might seem to be, the attempt to justify de-extinction on this basis remains problematic.

The first obstacle that de-extinction projects encounter in this regard is that, in most cases, the organisms that would be created will have different genetic profiles than their predecessors. This is due in part to the way in which some de-extinction techniques require the use of biological surrogates; it is also partly due to the fact that DNA degrades after organisms

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die, and without an intact genome, scientists must try to piece one together from fragmentary sources.¹⁸ Hence, with the passenger pigeon's revival, the technique being utilized will produce a hybrid of passenger and band-tailed pigeons, one that researchers hope will have most of the phenotypic traits of the former, but know will have some of the genotypic traits of the latter.¹⁹ Something similar is likely to be true if attempts to recreate the woolly mammoth ever prove successful: “[I]f we’re going to see anything mammoth-like at all,” says Brian Switek, “it’s much more likely that it will be an elephant modeled after our best guess at what a mammoth is.”²⁰

Even if genetic divergence was not an issue, however, the troubles that de-extinctionists face on this score would persist. At least some animal behaviors are learned, and since every revived species will lack a namesake parental generation, certain of their distinctive behaviors will surely be lost.²¹ Band-tailed pigeons, for instance, may be able to serve as biological surrogates for passenger pigeons, yet the two species have different behavioral characteristics and, perhaps most importantly, different migratory patterns. Because of this, Richard Stone reports, the research team tasked with reviving the extinct bird “intends to use passenger pigeon puppets as parental simulacra. But puppets can’t teach young pigeons how to migrate. If the team gets that far...it will paint the plumage of another migratory species, the homing pigeon, in the colors of their extinct cousins and release tagged passenger pigeons to the surrogate flock.”²²

Such issues rightly raise doubts in the minds of many about whether or not species revival projects actually live up to their name. Sherkow and Greely, for example, question what it is that de-extinctionists might really engender, noting that “revived individuals would not have the same epigenetic makeup, microbiome, environment, or even ‘culture’ as their extinct predecessors.”²³ Switek claims that “the fundamental truth [is] that ‘revive and restore’ projects

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are actually creating new species rather than truly resurrecting what was lost.” For him, “de-extinction—in a literal sense—fails its own premise.”²⁴

Such considerations form a compelling case against the notion that we can make restitution to extinct species via resurrection projects. Nevertheless, it might still be argued that researchers should be encouraged to continue their efforts. After all, that we cannot right past wrongs completely does not mean that we should not try to right them at all, and in response to anthropogenic extinction it may be that we will have done our moral best if proxies of vanquished species could populate the landscape. Unfortunately for those who would offer this argument, however, the defense of de-extinction as a type of “approximate” restitution to species also comes up short, and for two primary reasons.

The first reason is that, regardless of whether one thinks that de-extinction revives old species or engineers new ones, the organisms it produces will need somewhere to go, and placing re-created exemplars of charismatic animals on display in zoos is surely more a punishment for them than a penance for us. If this need is taken seriously, though, it would obligate revival advocates to de-emphasize species resurrection and prioritize precisely the sorts of habitat and wildlife protection concerns that are the real drivers of anthropogenic extinction, since without this, the most probable result of de-extinction projects would be, in a word, “re-extinction.”²⁵

The second thing that needs to be considered here is that any restitutive act involving either a resuscitated species or its re-tooled proxy would have to be ecologically responsible and sensitive to other values in the landscape. Yet currently the risks associated with species revival and reintroduction are highly uncertain. Several authors point out that the re-appearance of many extinct species could be the ecological equivalent of deliberately introducing an invasive species.²⁶ Zimmer says that because most species will be re-engineered versions of their

predecessors, releasing them into natural areas could be “in effect, the introduction of a genetically engineered organism into the environment.”²⁷ Sherkow and Greely add to this list of reservations that “de-extinct creatures might prove excellent vectors for pathogens.”²⁸

The upshot, therefore, is that even when revival projects are viewed only as approximate restitutive measures, they come with a heavy ethical burden that they appear to be unable to bear. There is, however, at least one other rationale for these projects that we have not considered thus far, one that promotes de-extinction as a means of compensating for human degradation of natural systems. But can the goal of revitalizing natural systems justify reviving extinct species?

Restoration of Systems?

Although the notion that we should not compromise ecological systems is consonant with both anthropocentric and non-anthropocentric outlooks, the claim that ecosystems are valuable in themselves, like the belief in the intrinsic value of species, is a contentious one.²⁹ It is true, though, that here, as before, many ecologists, biologists, and natural resource specialists espouse the view that ecological systems ought to be valued for their own sakes. Perhaps most famously, such a systems-oriented ethical holism was expressed by Aldo Leopold in *A Sand County Almanac*, where he declared that “[a] thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.”³⁰

Without doubt, such an eco-centric orientation can ground strong concerns about human impacts on natural systems. Within this framework, however, both these concerns and the agendas for restoration that follow them can take different forms. On some models, anthropogenic environmental changes are seen as problematic if they fail to preserve the species assemblages traditionally present in ecological regions, a failure that is thought to diminish these

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areas' value by diminishing their unique biological and ecological characters. On such accounts, then, restoration will stress fidelity to the historical components of ecosystem types, and have as a primary aim the maintenance of species and populations within their native ranges.³¹ On other models, eco-centric concern is for the ways in which human activities can reduce the biological productivity, evolutionary potential, or capacities for self-renewal that systems normally possess. On these views, which J. Baird Callicott characterizes as more “dynamic and functional” than “structural and static,” restorative practices will tend to de-emphasize traditional species associations, and focus more on helping ecosystems regain the aforementioned aspects of their functional integrity, aiding them to recoup what Leopold aptly referred to as “land health.”³²

Considering what de-extinction entails, it might be thought to align with the more “structural” of the restoration models just described. Yet Stewart Brand suggests that the real aim of these projects is more “functional” than that. “It is expected,” he says, “that the revived species will be nearly identical genetically, and ‘functionally identical’ ecologically [to their extinct predecessors]. They should be able to take up their old ecological role in their old habitat. Revived woolly mammoths, for example, should be able to convert parts of the northern boreal forest and tundra into ‘mammoth steppe’ grasslands, as they once did.”³³ Part of what Brand is doing here, of course, is trying to quell fears that de-extinction may not bring back the same species that were driven to extinction. In the process, however, he stresses both an ecological conception of species, and a functional view of why resurrecting them matters.

Brand’s assurance notwithstanding, the position he advocates faces several challenges, prominent among which is that de-extinction projects could turn out to be counter-productive to many efforts at ecological restoration. The reason for this, briefly stated, is that while levels of uncertainty and ecological risk associated with restoration practices vary, they are typically quite

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high when the practice in question is the resurrection of a species.³⁴ Detailed knowledge of how extinct species interacted with their environments is often poor, as is knowledge of how their respective ecosystems have changed in their absence.³⁵ To this can be added worries about ongoing ecological disturbance resulting from global climate change, as well as the possibilities mentioned earlier that revived organisms may carry disease or behave differently than their long-lost kin.³⁶ It seems incredible, therefore, that Brand would assert so confidently that revived species “should be able to take up their old ecological role in their old habitat.” In many cases neither their “old role” nor their “old habitat” is thoroughly understood, re-created organisms may be ill-suited to both, and the systems they formerly inhabited may no longer exist.

The point of these remarks, it should be stressed, is not to imply that humans have no obligations to engage in certain types of “restitutive restoration.”³⁷ It is beyond doubt that we have caused a great deal of environmental harm by way of our destruction of species, and we should assume neither that this damage is irreparable, nor that we have no duties whatsoever to try to repair it. Yet the claim that we bear a responsibility to make restitution to natural systems is not equivalent to the claim that ecological restoration should proceed specifically by way of de-extinction projects. Indeed, viewed in light of what we have been saying, such an approach to restoration looks much more like a grand experiment in engineering natural systems than a morally sincere attempt at making restitution to them.

For Nature’s Sake?

Despite all of the above, some will still have trouble relinquishing the notion that revival projects represent our best chance of making amends for anthropogenic extinction. Nonetheless, the moral ground that de-extinction advocates have tried to claim is less solid than it might first

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appear, as the restitutive case for reviving species is much harder to make than it may initially have seemed. This point having been made, however, there remains an additional and perhaps more basic problem with de-extinction that ought to be mentioned, and thus we will do well to address it as we bring this analysis to a close.

In commentaries on de-extinction, one regularly finds conservationists expressing the worry that research in this area could hinder biodiversity protection. Often, their concern is that expensive but high-profile resurrection projects have the potential to divert limited funding away from other, less flashy but perhaps more effective species preservation efforts.³⁸ Sometimes, however, the concerns voiced are less pragmatic and more about the deeper assumptions embedded in the notion of de-extinction itself. Stuart Pimm, for example, says that the idea of de-extinction fosters “the expectation that biotechnology can repair the damage we’re doing to the planet’s biodiversity...,” and fears it may lead people to think there is no need to save endangered species since we “can simply keep their DNA and put them back in the wild later.”³⁹

What this comment reveals, above all, is how readily the idea of reviving species fits into a contemporary narrative in which getting things straight with other forms of life is not a matter of decreasing human excesses, but of artificially enhancing nature’s ability to withstand them. What Pimm highlights, that is, is the sort of technological optimism that animates the resurrection ideal, one that suggests, in effect, that the appropriate response to anthropogenic extinction is not to pay more careful attention to the limits of other species’ tolerance for us, but for us to find new and better ways to push those limits further. The all-too-easy take-away from the restitutive story of de-extinction, it seems, is that we need not a less intrusive manner of engaging with the nature, but more effective methods of mastering it; not that other forms of life need less of our impact upon them, but that they require more of our ingenuity and know-how.

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Looked at in this way, it is not difficult to see how the promotion of species revival projects aligns with some of the major themes of “Anthropocene discourse” that Eileen Crist has recently described. These include the beliefs that “technology, including risky, centralized, and industrial-scale systems, should be embraced as our destiny and even our salvation,” that “major technological fixes will likely be needed, including engineering climate and life” and that “the path forward lies in humanity embracing a managerial mindset and active stewardship of Earth’s natural systems.”⁴⁰ The problem with this orientation, of course, as Crist herself is quick to point out, is that by calling us to “the high road of becoming good managers of the standing reserve,” it thereby “masks an invitation to opt for the low road of rationalizing (and relatedly ‘greening’) humanity’s totalitarian regime on Earth.”⁴¹

In the end, then, it is precisely this invitation to such “low road” rationalizing of human mastery that appears most troublesome about de-extinction. Resurrection projects are presented in non-anthropocentric terms as restitution to our other-than-human kin, a penance we ought to pursue for nature’s sake, while at bottom they reflect the same sort of instrumentalizing rationality that fuels so many environmental wrongs in the first place. As Switek has put it, “[s]o snugly and warmth-inducing is the concept that it’s quite easy to overlook the hubris involved in effort, revealing that ‘de-extinction’ is not a literal translation of fact but a euphemism for engineering a future nature that we find wonderful and satisfying.”⁴² Hence, borrowing from Crist, we might simply conclude that what we really need, more than or perhaps instead of techniques for re-assembling and re-animating life forms, is to accept “the *priority* of our pulling back and scaling down, of welcoming limitations of our numbers, economies, and habitats for the sake of a higher, more inclusive freedom and quality of life.”⁴³

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- ¹ Julia Leigh, “Back From the Dead,” *The Guardian*, Wednesday May 29, 2002, accessed at <http://www.theguardian.com/science/2002/may/30/genetics.australia>; Luba Vangelova, “True or False? Extinction Is Forever,” *Smithsonian Magazine* 34, 3 (June 2003): 22.
- ² Richard Stone, “Fluttering from the Ashes?,” *Science* 340, 6128 (April 2013): 19; Carl Zimmer, “Bringing Them Back to Life,” *National Geographic* 223, 4 (April 2013): 32-3, 36-7.
- ³ Zimmer, “Bringing Them Back to Life,” p. 30.
- ⁴ Jacob S. Sherkow and Henry T. Greely, “What If Extinction Is Not Forever?,” *Science* 340, 6128 (April 2013): 33.
- ⁵ Paul W. Taylor, *Respect for Nature: A Theory of Environmental Ethics* (Princeton: Princeton University Press, 1986).
- ⁶ *Ibid.*, p. 187.
- ⁷ *Ibid.*, p. 188.
- ⁸ *Ibid.*, p. 188. Peter Wenz, in *Environmental Justice* (Albany: SUNY Press, 1988), argues that Taylor’s account of restitution is untenable, based in part on the claim that it cannot be extended as far as Taylor suggests that it can be (see Wenz pp. 287-91). For our discussion here, however, the details of Wenz’s critique are not critical.
- ⁹ Nicholas J. McBride and Paul McGrath, “The Nature of Restitution,” *Oxford Journal of Legal Studies* 15, 1 (Spring 1995): 33-49.
- ¹⁰ Certainly, trophic cascades and other ecological effects of anthropogenic extinction impact multiple generations of organisms. While concerns about these effects could be expressed in a manner consistent with an individualistic ethical framework, they are probably better understood in the systems-oriented terms discussed later in this essay.
- ¹¹ Taylor, *Respect for Nature*, p. 188.
- ¹² Brand, “Revive and Restore Project Frequently Asked Questions”; Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 32.
- ¹³ See, e.g., Elizabeth Pennisi, “The Lamb That Roared,” *Science* 278, 5346 (December 1997): 2038. The question of genetic clones and individuality is also discussed by Gary Varner, *In Nature’s Interests? Interests, Animal Rights, and Environmental Ethics* (Oxford: Oxford University Press, 1998), pp. 74-6.
- ¹⁴ One of the more interesting individualistic approaches to the ethics of species is found in Nicholas Agar, “Valuing Species and Valuing Individuals,” *Environmental Ethics* 17, 4 (Winter 1995): 397-415. The central themes of this article are elaborated upon in Agar’s *Life’s Intrinsic Value: Science, Ethics, and Nature* (New York: Columbia University Press, 2001). Holmes Rolston’s perspective on the value of species has been advanced in many venues, including his *Environmental Ethics: Duties to and Values in the Natural World* (Philadelphia: Temple University Press, 1988).
- ¹⁵ Michael Soulé, “What Is Conservation Biology?,” *BioScience* 35, 11 (December 1985): 730.
- ¹⁶ *Ibid.*, p. 731.
- ¹⁷ Brand, for instance, echoes Soulé’s normative emphasis when he says that one of the primary motives for pursuing species revival projects is “to preserve biodiversity and genetic diversity” (“Revive and Restore Project Frequently Asked Questions”).
- ¹⁸ See Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 32; Zimmer, “Bringing Them Back to Life,” pp. 36-7; Brian Switek, “Reinventing the Mammoth,” *National Geographic*, March 19, 2013, accessed at <http://phenomena.nationalgeographic.com/2013/03/19/reinventing-the-mammoth/>; Brand, “Revive and Restore Project Frequently Asked Questions.”
- ¹⁹ Stone, “Fluttering from the Ashes?,” p. 19; Brand, “Revive and Restore Project Frequently Asked Questions”; Zimmer, “Bringing Them Back to Life,” pp. 32-3, 37.
- ²⁰ Switek, “Reinventing the Mammoth.”
- ²¹ See David Ehrenfeld, “Extinction Reversal? Don’t Count on It,” YouTube video, posted on *The Long Now Foundation* website, April 2, 2013, accessed at <http://longnow.org/revive/tedxdeextinction/extinction-reversal-dont-count-on-it/>; Switek, “Reinventing the Mammoth”; Vangelova, “True or False? Extinction Is Forever,” p. 22.
- ²² Stone, “Fluttering from the Ashes?,” p. 19.
- ²³ Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 32.
- ²⁴ Switek, “Reinventing the Mammoth.”
- ²⁵ Stuart Pimm, “The Case Against Species Revival,” *National Geographic*, March 12, 2013, accessed at <http://news.nationalgeographic.com/news/2013/03/130312--deextinction-conservation-animals-science-extinction-biodiversity-habitat-environment/>.

²⁶ Stone, “Fluttering from the Ashes?,” p. 19; Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 32; Donald S. Maier, *What’s So Good About Biodiversity? A Call for Better Reasoning About Nature’s Value* (Dordrecht: Springer, 2013), p. 315.

²⁷ Zimmer, “Bringing Them Back to Life,” p. 41.

²⁸ Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 32.

²⁹ Notable among the critics of ethical holism in environmental ethics is Tom Regan, whose claim that such holism is a form of “fascism” has been widely cited. See Regan’s *The Case for Animal Rights* (Berkeley: University of California Press, 1985), p. 362.

³⁰ Aldo Leopold, *A Sand County Almanac* (New York: Ballantine Books, 1970), p. 262.

³¹ A representative example of this perspective is found in A. Starker Leopold, et al., “Wildlife Management in the National Parks,” *Transactions of the Twenty-Eighth North American Wildlife and Natural Resources Conference*, ed. James B. Trefethen (Washington, D.C.: Wildlife Management Institute, 1963), pp. 29-44. Reprinted in *The Great New Wilderness Debate*, ed. J. Baird Callicott and Michael P. Nelson (Athens: University of Georgia Press, 1998), pp. 103-19.

³² J. Baird Callicott, “Aldo Leopold’s Concept of Ecosystem Health,” *Beyond the Land Ethic: More Essays in Environmental Philosophy* (Albany: SUNY Press, 1999), pp. 338-9. Rolston illustrates a similar rationale for restoration when he writes: “We are not resetting the forest to what it was a century ago. That suggests going backward in time, and that is impossible. We do not replace the past. We can only today put back in place products of nature...and, with this, encourage the reappearance of what we are really putting back: natural processes.” “Such restoration,” Rolston says, “is restitution...” (*A New Environmental Ethics: The Next Millennium for Life on Earth* [New York: Routledge, 2012], p. 185).

³³ Brand, “Revive and Restore Project Frequently Asked Questions.”

³⁴ For commentary on the risks associated with some of the more controversial species preservation measures, as well as how they might be assessed, see Ronald L. Sandler, *The Ethics of Species: An Introduction* (Cambridge: Cambridge University Press, 2012), especially chapter 4. Although Sandler does not address directly the topic of de-extinction, the discussion he provides is in many ways applicable here.

³⁵ See Brian Switek, “The Promise and Pitfalls of Resurrection Ecology,” *National Geographic*, March 12, 2013, accessed at <http://phenomena.nationalgeographic.com/2013/03/12/the-promise-and-pitfalls-of-resurrection-ecology/>; Switek, “Reinventing the Mammoth”; Pimm, “The Case Against Species Revival”; Maier, *What’s So Good About Biodiversity?*, p. 315.

³⁶ Many commentators raise the question of how climate change relates to de-extinction efforts. A general analysis of how climate change may require conservation biologists to re-think strategies for species preservation is provided by Sandler in *The Ethics of Species*, chapters 3-5.

³⁷ Though de-extinction is not the subject of his essay, the phrase “restitutive restoration” is borrowed from John Basl, “Restitutive Restoration,” *Environmental Ethics* 32, 2 (Summer 2010): 135-47.

³⁸ Sherkow and Greely, “What If Extinction Is Not Forever?,” p. 33; Stone, “Fluttering from the Ashes?,” p. 19; Zimmer, “Bringing Them Back to Life,” p. 40; Vangelova, “True or False? Extinction Is Forever,” p. 22.

³⁹ Pimm, “The Case Against Species Revival.”

⁴⁰ Eileen Crist, “On the Poverty of Our Nomenclature,” *Environmental Humanities* 3 (2013): 130.

⁴¹ *Ibid.*, p. 144.

⁴² Switek, “Reinventing the Mammoth”

⁴³ Crist, “On the Poverty of Our Nomenclature,” p. 144.