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Perspectives

In Dire Straits: The Resurrection and Extraction of the Dire Wolf, and the Current Colonial Basis of De-extinction Science

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Abstract In April of 2025, the for-profit biotech company Colossal Biosciences garnered mass media attention by announcing they had "de-extincted" the dire wolf (*Aenocyon dirus*) with the use of CRISPR gene-editing technology. Colossal and others heralded it as the future of endangered species conservation. In response, many in the larger scientific and conservation communities qualified or dismissed the claims to de-extinction based on sound genomic, phylogenetic, and taxonomic evidence. This debate, however, has occurred almost entirely within the confines of Western science and epistemology. We expand these critiques by highlighting the colonial, eugenic, and anthropocentric ideologies prevalent in Colossal's approach to de-extinction, exemplified by what we call a "colonial grabbag" mythological framing of wolves. We argue that this is reflective of the larger colonial basis of current de-extinction science. Grounded in the fields of Indigenous Science and Animal Studies, we invite further reflection on the strategic, ethical, and moral considerations of de-extinction. Rather than arguing that such technologies and aims should be categorically rejected, we offer recommendations toward an anti-colonial and anti-anthropocentric science of de-extinction that is based in equity, reciprocity, and collective social good. We propose 1) a shift away from the isolationist approach that "resurrects" a species without regard for the larger ecosystem in which they existed in favor of a holistic ecology; 2) focusing the tools of de-extinction on currently threatened and endangered species and ecosystems; and 3) centering Indigenous Science and place-based knowledges by practicing transparent and sustained consultation and collaboration with Indigenous Nations.

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Introduction

In this perspectives paper, we examine biotech company Colossal Bioscience's "de-extinction" of the dire wolf (*Aenocyon dirus*) through the lenses of Indigenous Science and Animal Studies to reveal the colonial, eugenic, and anthropocentric ideologies prevalent in their approach to de-extinction. We contend that Colossal relies on a "colonial grabbag" mythological framing of wolves that is reflective of the larger colonial basis of current de-extinction science. We then consider the strategic, ethical, and moral dimensions of de-extinction, and argue that such technologies could be redirected toward an anti-colonial and anti-anthropocentric science of de-extinction based in equity, reciprocity, and collective social good. We propose 1) a shift away from the isolationist approach that "resurrects" a species without regard for the larger ecosystem in which they existed in favor of a holistic ecology, 2) focusing the tools of de-extinction on currently threatened and endangered species and ecosystems, and 3) centering Indigenous Science and place-based knowledges by practicing transparent and sustained consultation and collaboration with Indigenous Nations. These recommendations also contribute to a "diverse conservation inventory" (see Gibson-Graham and

Dobroski 2020; Gillette et al. 2023) that articulates practices of conservation and ecological stewardship beyond capitalist hegemony.

What falls under the purview of de-extinction, though? De-extinction remains conceptually nebulous, with no single definition having scientific consensus. Some restrict the term to the literal re-creation of taxonomic-level extinct species through synthetic biology, cloning, genetic engineering, or reproductive technologies (Valdez 2019). Others adopt a more expansive framing, positioning de-extinction as the production of organisms that "resemble" or function as "proxies" for species that no longer exist (Seddon and King 2019; Shapiro 2017). Still further, a growing body of work pushes beyond species-level thinking altogether. This work suggests that the resurrection of particular genes or phenotypic traits may also constitute meaningful forms of de-extinction (Seddon and King 2019), while others emphasize the restoration of ecological roles as a defining criterion for successful de-extinction (Turner 2025).

In this paper, we focus on an example of the broader conceptualization: the genetic editing of gray wolf (*Canis lupus*) embryos to incorporate genes from the extinct dire wolf. While debates continue over whether de-extinction properly refers to species, traits, or genes, the urgent ethical, ecological, and conceptual questions we raise are relevant across all these definitions and scholarly positionings.

De-extinct or Designer? Colossal Bioscience's Dire Wolf Blitz

Colossal Biosciences garnered massive media attention in April 2025 when they announced they had "resurrected" the long-extinct dire wolf and proudly introduced their three canines to the world: brothers Romulus and Remus, and their younger sister, Khaleesi. A striking photo of Romulus graced the cover of *Time* magazine, and pictures and videos of the entire trio were featured in marquee publications from *The New Yorker* to *The Hollywood Reporter*. Colossal trumpeted the dire wolves as a groundbreaking scientific achievement—one that presages the future of not just genomics, but also conservation.

As Jeffrey Kluger wrote for *Time*, Colossal's executives "often frame the technology not just as a moral good but a moral imperative—a way for humans, who have driven so many species to the brink of extinction, to get square with nature" (Kluger 2025). The rhetoric from Colossal's website also makes clear that the company considers itself to be the vanguard of de-extinction science: "Extinction is a colossal problem facing the world, and Colossal is the company that's going to fix it" (Colossal Biosciences 2025a). With more than a half-billion (and counting) in venture capital funding, Colossal has ambitions to de-extinct other charismatic megafauna such as the Woolly Mammoth, Tasmanian Tiger or Thylacine, the Dodo, and the Moa.

The commensurately "colossal" acclaim and notoriety of the dire wolf's return did not, however, drown out the cacophony of criticism from the larger scientific community. Paleontologists, geneticists, biologists, and scientists and advocates of all stripes took aim at the premises of these supposed genetic marvels. The majority of critiques centered around Colossal's use of CRISPR gene-editing technology to produce the animals. By extracting viable dire wolf DNA from a tooth and inner ear bone, Colossal claims to have recovered 0.1% of the entire genome. This ancient DNA was then used to make 20 edits of 14 gray wolf genes, which, Colossal says, produced discernibly "dire" morphological and phenotypic characteristics such as larger size and white pelage (fur/hair) (Colossal Biosciences 2025c). While inarguably innovative, critics pointed out that gray wolves have about 20,000 genes, and altering 0.1% of them does not a dire wolf make. Others pointed to the Perri et al. 2021 paper in *Nature* which argued that, though morphologically similar to gray wolves, dire wolves were "from a highly divergent lineage," and there was no evidence of gene flow between the two species. This camp dismissed the dire wolves as "designer" or "GMO" gray wolves. Beth Shapiro, Colossal's chief scientist, has since walked back claims of de-extinction, stating that Romulus, Remus, and Khaleesi are "gray wolves with 20 edits" and that the company uses the name "dire wolf" "colloquially" (Le Page 2025). This important qualification, however, does not seem to have changed the overall framing or marketing of the canids in Colossal's public communiques.

Alongside genetic, taxonomic, and phylogenetic debates are political and ethical concerns. What, exactly, are the ramifications of this technology from an environmental and conservationist standpoint? How does it articulate with government-sponsored wildlife management and protections? Should we really be outsourcing our collective hopes of halting or

reversing rampant species loss and habitat destruction to a billionaire-backed private company? This is to say nothing of the welfare of the dire wolves themselves, and any forthcoming resurrections. According to Colossal, their dire wolf trio is healthy and roaming in a 2,000-acre enclosure in an undisclosed location while under constant surveillance. Lost in the media frenzy was the fact that a fourth pup in the litter died after 10 days (Black 2025). Though not necessarily ethically damning, the neonatal death raises questions regarding the qualitative aspects of nonhuman lives that may be appropriated, damaged, or destroyed in the quest for de-extinction. Whom does this de-extinction serve? What does this portend for humanity's relationship to nature?

Collaboration or Co-optation? Colossal's Partnerships with Tribal Nations

Colossal has assembled a staggeringly large, star-studded roster of academics, entrepreneurs, politicians and celebrities to support their efforts. And, to the company's credit, conservation and ecosystem restoration are consistently named as lodestars. Additionally, Colossal at least appears to be meaningfully including Indigenous partners and stakeholders. They list partnerships with the Karankawa Tribe in Texas, the Nez Perce, and the MHA (Mandan, Hidatsa, and Arikara) Nation. Mark Fox, MHA Nation Tribal Chairman, serves on Colossal's "Indigenous Council" among other Native advisors. Collaborations such as these, and the inclusion of Indigenous perspectives in the de-extinction debates, have helped somewhat temper fears of a loose-cannon biotech company "playing God," accountable to no one but its uber-wealthy investors. Though the "Jurassic Park" allegations abound, Colossal seems to embrace them (Snedegar 2024). Perhaps the science of de-extinction can be a collective good for humans and nature, rather than something to amuse plutocrats while the rest of the world burns.

Despite these promising partnerships, it is worth noting that while Colossal has selected a range of flagship species from around the world—like the Thylacine in Australia and the Moa in New Zealand—their Indigenous Council includes only Native American representation. This configuration makes the council potentially ill-equipped to address issues of de-extinction for Indigenous peoples outside of current day North America, a critical consideration given the differing views of de-extinction among Indigenous peoples around the world (Rawlence and Wilcox 2025). Even within the U.S. context, Colossal's Indigenous representation is limited to only a handful of individuals from a small number of tribes (compared to the more than 500 federally recognized tribes alone) and it is unclear what level of involvement and decision-making the Indigenous Council has. Transparent and robust consultation with the tribes who may be geographically impacted by the dire wolves' de-extinction and potential reintroduction, as well as collaboration with Indigenous scholars and scientists specializing in genomic science, ecology, environmental science, and animal studies is also an important step.

The immense potential of Colossal's collaborations with Tribal Nations is also compromised by the company's strange bedfellows. Indeed, while trumpeting its conservationist stances and Tribal partnerships, Colossal is simultaneously courting partnerships with those actively undermining Native sovereignty and environmental protections. The grinning face of the U.S. Secretary of the Interior, Doug Burgum (2025), perplexingly appears on the dire wolf page on Colossal's website (Colossal Biosciences 2025a) alongside a quote:

> Since the dawn of our nation it has been innovation–not regulation–that has spawned American greatness…The dire wolf revival is more than a scientific triumph, it carries profound cultural significance as it embodies strength and courage that is deeply encoded within the DNA of American identity and tribal heritage.

This is from a longer statement where Burgum implies that U.S. Endangered Species protections have been a failure, and that it is rather de-extinction technology that will ensure "populations are never at risk." Shortly after the dire wolf unveiling, reports emerged that Burgum had already held meetings with Colossal Executives about possible partnerships. The Trump administration has also directly cited Colossal's groundbreaking achievement as evidence for why the crucial 1973 Endangered Species Act is now obsolete (Grandone 2025). The gutting of protections for a host of endangered species looms, which include still-living, wild gray wolves (Drew 2025).

This comes as the Department of the Interior also repeals environmental protections to incentivize oil and gas extraction, often disregarding the importance of these issues for Native culture and sovereignty

(Palmer 2022). This is coupled with the GOP's proposed billion-dollar cuts to tribal programs that support clean drinking water and housing in Indian country (Oxendine 2025)[1]. One incisive critique of these legislative moves came from former Hopi Tribal Vice Chairman and rancher Clark Tenakhongva. In an article for *High Country News*, Tenakhongva linked the recent slaying of two endangered Mexican gray wolves (*Canis lupus baileyi*) to the Trump administration's environmentally destructive and anti-Indigenous policies. "Much like wolves," wrote Tenakhongva (2025), "[the Hopi] have now been confined to a remnant of our original lands, fenced in with arbitrary lines that do not represent our deep history, knowledge and kinship to the land." Tenakhongva's poignant diagnosis further underscores the Trump administration's multi-pronged, settler-colonial violence against Native Americans and Indigenous animals. This hardly seems aligned with Colossal's professed values of "preserving and protecting a pristine nature" and "respect for all living things," (Colossal Biosciences 2025f) and certainly not with the interests of Tribal Nations. Colossal's paradoxical range of partnerships are, at best, hypocritical.

With a $10 billion valuation and backing from numerous Venture Capital firms, Colossal follows the trend of a traditional for-profit company, unlike peer start-ups that are attempting to create and pursue models of community benefit sharing and social good (Variant Bio 2024). The capitalistic engine feverishly driving Colossal's science and de-extinction projects places them squarely at the colonial socioeconomic foundation of the U.S., making choices based on extraction and objectification rather than sustainability and equity. Colossal's choice to begin their de-extinction campaigns with the dire wolf—an animal with mythical status and fantastical appeal—further evidences these extractivist logics.

Why Dire Wolves? Indians, Vikings, Romans, and the Making of Charismatic Megafauna

As opposed to woolly mammoths and the other long-extinct animals listed on Colossal's resurrection roster, the dire wolf was perhaps the most scientifically and logistically expedient. But wolves, dire and otherwise, have also been sociohistorically imbued with potent symbolic power, making them particularly well-suited to the marketing and commodification blitz we witnessed when the dire wolf's return was announced.

Wolves have always exerted a vice-grip on the Western imagination. Euro-American ideologies and mythos cast them as savage and rapacious beasts, catalyzing centuries-long wolf extermination campaigns that coincided with the genocidal and ecocidal logics of Manifest Destiny (Coleman 2004; Robinson 2005). In contrast, environmentalist and countercultural elements of the twentieth century rehabilitated the canid's image along with the concept of "wildness" itself (Cronon 1996; Fletcher 2014). Contemporarily, the wolf is often deployed to symbolize this romantic wildness, and a pristine nature that is to be preserved from the despoilment of an encroaching civilization. In both these seemingly antithetical anthropomorphic renderings of wolves, there are direct associations and conflations with Native Americans, with the former denigrating both wolves and Indians as "savage" threats to Christian civilization, and the latter glorifying the wolf-Indian dyad as inherently ecological "spirit guides" and "spirit animals" (Krech 1999; Marvin 2012:159). Despite myriad settler-colonial appropriations and distortions, the *actual* wolf is a friend, relative, teacher, and ceremonial figure for many Native American peoples (Pavlik 2014; Pierotti and Fogg 2017). Given its PR strategies, Colossal is keenly aware of such connections—both real and imagined—and is using them to strategically accrue cachet as a culturally conscious and ethical company.

Even more prominent than the Native American themes in Colossal's dire wolf messaging is a generically Viking and Nordic aesthetic. This is exemplified by the company's collaborations with fantasy author George R. R. Martin of *Game of Thrones* (GoT) fame, and actors Kit Harrington and Sophie Turner, who starred in the series' TV adaptation as members of House Stark. All three serve as "cultural advisory board members" for Colossal, and Martin is an author on the pre-print scientific paper on the dire wolf resurrection (Gedman et al. 2025). In the world of GoT, the Starks serve as a loose corollary to real-world Viking and medieval Scandinavian warrior societies, with the dire wolf being the House's patron animal. Several Stark nobles have dire wolf familiars, who were represented through a combination of canine actors and CGI. The TV series was a global sensation, and its popularity, more than any other single factor, catapulted the dire wolf into the pop-culture zeitgeist. Correspondingly, Colossal's dire wolf representations are in lockstep with GoT celebrity power, also exemplified by naming the female dire

wolf puppy Khaleesi, after another one of the series' protagonists.

While perhaps benign at first blush, the cultural matrix of wolves, Vikings, Nords, and paganism has also unfortunately been appropriated to propagate white supremacy and white nationalist populism (Gardell 2003), as well as eco-fascist ideologies (Hart 2021). The Nazis, for example, upheld wolves and certain dog breeds as avatars for Aryan "loyalty, hierarchy, fierceness, courage, [and] obedience" (Sax 2000:75). This phenomenon is also deeply intertwined with patriarchy and gender essentialism, as the idea of supposed "alpha" wolves who lead the pack by "dominating" and subjugating lesser "betas" and "omegas" is used to justify misogynistic, homophobic and transphobic worldviews.

The emergence of "alpha theory" or a linear dominance model of wolf sociality can be traced back to a handful of studies in the mid to late twentieth century (Schenkel 1947; Zimen 1976). However, many of these studies were based on observations of unrelated, orphaned wolf siblings in highly manipulated *captive* settings (Rabb et al. 1967). Given that wild or free-ranging wolf packs are usually multigenerational, extended family units, alpha terminology is seen by many wolf biologists as inappropriate and inaccurate unless applied to highly specific circumstances (Nordli et al. 2018; Packard 2003). The rate of conflict within and between wolf packs is influenced by the complex interplay of many abiotic and biotic environmental factors, such as seasonality, topography, overall prey density and the proximity to neighboring packs, rather than an innate instinct to forcibly subjugate conspecifics.

Though now largely discredited even by its former proponents (MacDonald 1983; Mech 1999; Zimen 1981:128), alpha-wolf ideology continues to circulate widely beyond ethological discourses on canids. Disappointingly, Colossal contributes to this trend, evidenced by a dire wolf puppy update video from their YouTube channel where the company's animal husbandry manager refers to Remus as occupying the "alpha role" while Romulus acquiesces as a "beta" (YouTube 2025a). This terminology is similarly reflected throughout Colossal's website in its description of gray wolves. Additionally, the very names of the dire wolf brothers are an homage to the founding myth of the Roman Empire, wherein two orphaned human brothers were suckled by a she-wolf as infants, literally imbibing the potent, undiluted wild energies that would come to fuel Roman dominance. The mythos of imperial Rome has, at least since Mussolini, also been a fountainhead of fascist symbolism and rhetoric (Nelis 2011; Tucci 2020).

In addition to the dominance-centered verbiage of alpha and beta, one only need to peruse Colossal's overwhelming website to recognize that the most salient features of the dire wolf, at least in the company's opinion, are its size, strength, power, and ferocity (Colossal Biosciences 2025c). Their descriptions of the dire wolf emphasize the animal as a "stunning" "apex predator," with "greater muscle mass," "larger teeth," and "greater shearing ability" [than the gray wolf]. In videos on Colossal's YouTube page, the pups are described as *bold, fierce,* and *adventuresome;* as the title of one video describes, "Khaleesi *conquers* the pool" (emphasis ours) (YouTube 2025b). Colossal has even created a Spotify playlist in homage to the dire wolf, titled "Big Bada$$ Wolf" (Colossal Biosciences 2025d). More troubling still is a sometimes subtle yet persistent focus on genetic uniqueness, purity, and superiority. Colossal assures us that dire wolves "occupy a lineage all their own," and that as far as genetics indicate, they did not interbreed with other canids such as gray wolves and jackals (Colossal Biosciences 2025c). Referenced are "the unique craniofacial features of a true American superwolf," with "suspected white fur." Indeed, Colossal's decision to edit a gene linked to white fur—again evoking the appearance of the iconic dire wolf "Ghost" from Game of Thrones—feels significant. This emphasis on genes tied to visible, phenotypic traits raises important concerns about the revival of aesthetic priorities reminiscent of eugenic narratives. It prompts the question: who determines which genes define a "dire wolf"? Are we privileging traits that produce visually striking, media-friendly animals, while overlooking genetic variants more critical to an individual's actual viability, such as those influencing immune function and overall health? Regardless of the answer, "after a 10,000+ year absence," Colossal is "proud to return the dire wolf to its rightful place in the ecosystem," (Colossal Biosciences 2025b) held up as a pure, white, symbol of power.

These Native American/Indigenous and Viking/Nordic/fantasy associations, along with a bewildering smattering of references to werewolf films, Dungeons & Dragons, literature and videogames, are all clumsily crammed into Colossal's dire wolf representations (Colossal Biosciences 2025d). These scattershot

anthropomorphic attributions work to discursively disfigure wolves, reducing them to a container, or a grabbag, of colonial conflations. With one hand, Colossal reaches into their lupine colonial grabbag to pull out any number of fungible shiny objects—devoid of cultural, ecological or species-specific context—to dazzle onlookers and investors. With the other, they extract literal and symbolic "animal capital" from wolves in the form of genetic material and psychic commodities (Shukin 2009).

One historical referent presaging the dire wolves' arrival goes notably unmentioned. Colossal's announcement, perhaps fittingly, comes around the centennial of the first documented attempt at species resurrection: that of the auroch (*Bos primigenius*), the bovine ancestor of modern domestic cattle. In the mid 1920s, German zoologists Lutz and Heinz Heck endeavored to back-breed the animal into existence by selecting auroch-like traits from extant breeds of cattle. Though they did not have CRISPR technology at their disposal, the Heck brothers, like Colossal, relied on "a range of archaeological, historical, and mythological materials" when claiming that they had de-extincted the species (Lorimer and Driessen 2016:635). But in this case, the range leads again to eco-fascism. Lutz Heck was an associate of the Third Reich's Hermann Göring, who aspired for aurochs to be one of many powerful, pure-blooded species that would rewild the forests of eastern Europe after the extermination of non-Aryan human populations. Thus, the animal was "absorbed by the grand vision of a collective racial rewilding" (Winthrop-Young 2023:230; see also Nyong'o 2015).

While in some ways a far-cry from the context of Nazi Germany, Colossal's efforts and rhetoric must be viewed not only alongside the history of genealogy, but also a genealogy of history (Foucault 1977). If the past is prologue, Colossal's traversal of the same ideological roads that lead back to Rome, or interwar Germany, does not inspire confidence. The problem is not just Colossal's troubling reliance on these symbolic associations with wolves, but that there are material consequences to the popularity of these narratives, including the creation of Romulus, Remus, and Khaleesi.

Dire Wolves and Relationality

If a larger cultural and colonial obsession with wolves has led to the "de-extinction" of a species, what of the individual wolves and their relations, including to other species and land? Colossal's desire to exert control over the dead does not just concern an abstract idea of a species, but has material impacts for those individual animals upon whom we have thrust the hope of conservation. Animal studies scholars encourage us to consider the material lives of animals (Desmond 2016), not just their symbolic status (Haraway 2007), and certainly not just their role as tools to achieve humanity's techno-scientific dreams or undo our environmental harms. Romulus, Remus, and Khaleesi are individual animals with specific needs, desires, and relations. They require care and are more than symbols of power touted on Colossal's website.

In reporting on Colossal's work, some media outlets emphasize that de-extinction provides a new approach to conservation, one that includes restoring relationships and landscapes that were severed or altered when dire wolves became extinct (for example, see Vespa 2025). But re-introducing long-extinct animals into a landscape and world that may not be habitable for them (and indeed is becoming less habitable for the currently living) hardly constitutes restoring relations. Dire wolves, as all living beings, exist in interdependent relations with other species in their ecosystems. For example, dire wolf genomes are estimated to have diverged from other canids (wolves, coyotes, dholes, jackals) around 5.7 million years ago (Perri et al. 2021). Although gray wolves have sometimes been considered functional or ecological "proxies" for dire wolves, they survived the Late Pleistocene megafaunal extinctions, whereas dire wolves did not. Canids such as gray wolves and coyotes (*Canis latrans*) may possess greater morphological plasticity and dietary flexibility than dire wolves, which likely helped them survive a mass extinction event (DeSantis et al. 2019; Perri et al. 2021; Saunders et al. 1998). Dire wolves, by contrast, went extinct during the same period as other specialized North American megacarnivores, including the American lion (*Panthera atrox*) and giant short-faced bear (*Arctodus simus*), highlighting their strong dependence on large prey (Perri et al. 2021; Saunders et al. 1998; Sotnikova and Rook 2010). This reliance on megafaunal prey—and the subsequent loss of these species from the ecological network—likely played a decisive role in the dire wolf's extinction (DeSantis et al. 2019; Graham and Mead 1987). Therefore, if dire wolves were reintroduced into ecosystems lacking the megafaunal prey base or plant communities that once sustained them, they could become ecologically isolated (Simberloff 1993). In

short, the reintroduction of *de*-extincted animals into ecological systems that no longer have the links to sustain them will lead to their *re*-extinction.

Colossal's efforts only raise further questions about how Romulus, Remus, Khaleesi, and potential future de-extincted animals might survive the current conditions of our planet, especially ecosystems that have long been unable to sustain them. Now that Romulus, Remus, and Khaleesi do exist in our world—dire wolf or not—what responsibility do we have to them (Haraway 2016)? How should we care for them in a world that is drastically different from the one in which their ancestors became extinct? And what would an anti-colonial approach to de-extinction look like?

Settler-colonialism continues to shape contemporary human-other animal relationships (Belcourt 2015; Hubbard 2014; TallBear 2015), and de-extinction is no exception. The current approach to de-extinction is a colonial one of isolation, in which individual animals are remade outside of their relation to land and kin within settler-colonial structures of land dispossession that impact humans and other animals alike. Scholar Billy-Ray Belcourt (2015:5) of the Driftpile Cree Nation argues that relationships such as domestication, and we would add de-extinction, exist "because of and through the erasure of Indigenous bodies and the emptying of Indigenous lands for settler-colonial expansion." Landscapes have changed dramatically since dire wolves went extinct 13,000 years ago. Environmental changes result from settler colonial impacts, including climate change, and the dispossession of Native peoples from their land that radically altered how many species—including humans, and now, the dire wolf—relate to the land. For example, the genocide of bison (often colloquially called buffalo)[2] in western North America to facilitate the genocide of Native peoples (Hubbard 2014) drastically altered the landscape and changed relationships between humans and buffalo. A keystone species, bison/buffalo were and are a significant relative that impacted all living beings on the Plains (Hubbard 2014). "Buffalo determine landscape," writes Winona LaDuke (1999:143; quoted in Hubbard 2014:292), highlighting the way that buffalo shaped their ecosystem in a reciprocal fashion. Similarly, as wolves are a keystone species, we can imagine the significant role that dire wolves had in their landscapes, and the importance of their kin relations for their existence. Now that climate change and settler-colonialism have altered our world, what do meaningful relations to ecosystems and kin look like for Romulus, Remus, and Khaleesi, who have no behavioral models of dire wolves to learn from, and whose ancestors went extinct in a different place? What does it truly mean to be labeled a "dire wolf" in a new environment, outside of relation, and without other dire wolves to teach them how to be (Rawlence and Knapp 2025)?

Khaleesi's, Romulus's, and Remus's specific relations that Colossal has named have been largely obscured and devalued. The pups are not simply animals brought into existence through human technological advancement; they have a flesh-and-blood surrogate mother who birthed and reared the pups, yet she is presented as a means to an end. From Colossal's website, their mother is a disembodied, nameless figure simply referred to as "domestic dog." As Colossal's "Science in Action" portion of the website reads, "Domestic dog will be the mother of wolves by nursing and caring for the pups." Their mother—a critical, living relation for the wolf pups—is not only left nameless, but is rendered relevant only insofar as she is a biological resource for the pups (Colossal Biosciences 2025e). She is mentioned only through her labor to nurse and care, a position that reflects misogynistic views of women in which their value lies in motherhood and an ability to provide (for) babies.

Another set of excluded and minimized relations are the so-called "donors." Colossal identified four gray wolves from whom they extracted Epithelial Progenitor Cells for editing (Colossal Biosciences 2025e). These gray wolves made it possible for the dire wolf pups to exist as they do, and are critical members of the social and biological web of "dire wolf" relations. Just like the "domestic dog" mother, we know little about these individuals; the pups are presented as isolated from them rather than in relation to them. Further, the term "donor" implies that the gray wolves consented to the use of their genetic material to produce Khaleesi, Romulus, and Remus. "Donor" here is merely a euphemism to conceal the role of human dominance in the process of de-extinction.

As the current approach to "de-extinction" lacks considerations of relationality, to what kind of life will Romulus, Remus, and Khaleesi be subjected? Is "dire wolf" purely a genetic category, a phenotypic one, or one made of a set of relations where the entire

ecosystem matters (Rawlence and Knapp 2025)? A respectful and anti-colonial approach to de-extinction involves caring for living animals and species, as well as the ways they are in meaningful relation. Expecting scientists to resurrect the dead to save us makes "de-extincted" animals nothing more than tools in service of human needs. As Colossal Biosciences and capitalist-driven de-extinction science show no signs of slowing down, how can we proceed in an anti-colonial and anti-anthropocentric way? In the final section, we present three potential areas for improvement.

Conclusion: Three Suggestions Toward an Anti-colonial and Anti-anthropocentric Science of De-extinction

Given its platform and resources, Colossal Biosciences has a unique opportunity to create greater awareness and scientific literacy about what these genomic processes can (and can't) do, as well as the larger biological and ecological systems of collapse that make them necessary in the first place. Instead, from their website's fonts to their glitzy advisory boards, to their use of multiple and colliding cultural narratives about dire/wolves, they have chosen a "colonial grabbag" approach—circulating anything, and nearly everything, a broader public might be drawn to about wolves. In doing so, they perpetuate not only colonial and white supremacist models of science, but also potentially the very narratives and behaviors that endanger wolves in the first place.

The authors of this paper represent a group of scholars engaged in studying the human-animal relationship from interdisciplinary perspectives, including Indigenous studies, anthropology, archaeology, linguistics, ecology, evolutionary biology, and genetics. We bring our diverse expertise and intellectual commitments to bear on the question of de-extinction, not to argue that it is inherently unethical or doomed to be a cautionary Jurassic Park-esque tale, but to call into question the ideological basis from which we dare to resurrect the lives and worlds of other beings. The methods used in de-extinction science (e.g., gene editing, genome sequencing, etc.) are tools that can be used in a variety of contexts. Here we argue that harnessing these tools in service of for-profit entities enmeshed within the dominant capitalist worldview will ultimately be harmful. Instead, using them to further projects that value respect for more-than-human kin, equitable partnerships with local communities, transparency, and reciprocity are more likely to help us realize our shared goals for biodiversity. Regardless of the many valid critiques of Colossal's efforts, Romulus, Remus, and Khaleesi already exist, and plans for more "dire" wolves have been announced. There is still a possibility for ethical approaches to their care and to the science which created them. There are many avenues that might be taken toward what we define as an anti-colonial and anti-anthropocentric science—and indeed politics—of de-extinction.

Recommendation #1: Shifting from Individualistic/ Isolationist Views of De-extinction to Holistic, Ecosystem-centric Views. Any project of de-extinction must recognize that ecosystems are complex, relational, and dynamic. Animals are embedded in ecological communities and are linked by direct and indirect interactions across trophic networks (e.g. foraging relationships that structure food webs; Hildrew and Giller 2023; Jonsson 2014) and mutualistic networks (e.g., reciprocal exchanges such as plant–pollinator systems; Bastolla et al. 2009). These dynamic interactions create interdependent ecological webs that can shift over time (Toju et al. 2024). When critical links in this network break or disappear, the ecosystem can unravel: the loss of mutualists or top predators can destabilize ecological network structure and trigger extinction cascades (Hale and Valdovinos 2020).

The revival of any single species therefore cannot, in isolation, restore ecological integrity nor prevent its further degradation. A shift is needed from reductionist approaches that focus solely on individual species or genes, toward perspectives that recognize extinction events as occurring within a broader web of interconnections—among kin networks, landscapes, and communities. Promises of biodiversity conservation and ecological restoration made by companies like Colossal Biosciences must account not only for biological *presence*, but for the potential of reweaving ecological and relational ties in which organisms have and will exist.

Recommendation #2: Focusing on Still-viable Ecosystems and Currently Threatened and Endangered Species. De-extinction methodologies may hold the most promise in contexts where the broader ecosystem and its kinship networks remain relatively intact, and where the reintroduction of recently extinct species or gene variants (e.g., key pollinators) may support the recovery of ecological processes vital to the maintenance of ecosystem function and resilience (see

de Flamingh et al., forthcoming). The tools of "de-extinction" could also have uses that benefit extant threatened and endangered species (Rawlence and Knapp 2025). We concur with paleogeneticists Nic Rawlence and Michael Knapp (2025), who argue that de-extinction technologies are better spent on living species threatened with extinction than on attempts to bring back the dead. Colossal's partnership with the Gulf Coast Canine Project and the Karankawa Tribe of Texas claims to do just that (Colossal Foundation 2024). An encouraging example that focuses on living populations threatened with extinction, this project aims to increase the genetic diversity of the red wolf (*Canis rufus*), the most critically endangered wolf in the world and the only species of wolf unique to North America, with around 20 left in the wild (Eanes 2025). To realize the potential of this partnership, however, Colossal must dispense with dangerous conflations of "genetic diversity" with "genetic purity," as seen in its renderings—literal and figurative—of the dire wolves. As methods of gene control become increasingly powerful, there must be a concomitant awareness to how bearers of "ancient," "rare," and "pure" genes are portrayed and discussed, whether they be human or more-than-human, lest the eugenic drift currently prevalent in discourses of de-extinction and conservation continue to proliferate.

Recommendation #3: On Ethical Indigenous Consultation and Collaboration, and the Foregrounding of Indigenous Science. This leads to our final major recommendation toward an anti-colonial and anti-anthropocentric science and practice of de-extinction: Indigenous peoples and place-based knowledges (also referred to as "traditional ecological knowledge" or TEK) should be at the center of de-extinction efforts. It is crucial to foreground processes of selection and format of Indigenous consultation, to demonstrate how exactly those consultations occur, and to be transparent on the subjects and scope of consultation and on who is invited to participate (and who declines). Critically, consultation should occur with tribal nations rather than only Indigenous individuals. Consultation should involve Native nations and communities in the specific contexts in which these new wolve—or other species—live or will be living. This consultation should also occur regarding the processes for how DNA "donor" species are acquired and accessed, and how they are cared for. Frameworks for ethical research with ancient DNA (Kowal et al. 2023) might be especially instructive in this area. In addition to those Indigenous Nations, there is a growing number of Indigenous geneticists and scientists who can provide much needed perspective on de-extinction projects.

There are already examples of how "de-extinction" science can be utilized in contexts where local communities are the stewards, and where place-based knowledge is used to inform decision making (Larsen and Johnson 2017; Myhal 2024; Myhal and Carroll 2023). For example, local tribes and peoples around the Klamath River in Southern Oregon and Northern California worked collaboratively for over two decades on the successful reintroduction of salmon to the ecosystem (Blumm and Illowski 2022; Mucioki et al. 2022). Local communities of practice worked together and asked questions about if, or when, sequencing genomes of species and ecosystems should be completed, where the data would be stored, and who would have access to that data. In this dialogic process, the benefits and detriments of gene drive or introduction of functional gene variants into a biological system could also be deliberated.

The recommendations we provided have implications far beyond Colossal Biosciences, as they are not the only player in the de-extinction game. These recommendations should be focal points for any company, entity, or coalition concerned with biodiversity, conservation, and ecosystem restoration (or at least, those who wish to engage in these pursuits ethically). The technological and scientific advancements showcased by Colossal can play a decisive role in addressing the mass extinctions and habitat loss of our so-called "Anthropocene" era (Swanson et al. 2017). But a dogmatic allegiance to privatized, techno-scientific breakthroughs will not save us, nor will adherence to a colonial conception of "wildness" that is devoid of human presence and action. Like wolves, buffalo, salmon, and all our more-than-human relations, we have an essential part to play in making livable, de-extincted futures that are grounded in an ethics of ecological stewardship, kinship, and reciprocity. For as large, powerful, pure, and mythologically super-charged as dire wolves may be, they alone will not save us from the decidedly dire ecological and climactic straits in which we find ourselves.

Notes

[1]To be clear, the current administration is not necessarily unique in its anti-Indigenous policies and rhetoric. For example, the Dakota Access Pipeline (DAPL), which began construction during the Obama

administration, violated the sovereignty of several tribal nations (see Estes 2019). The Obama administration remained relatively inactive as a Native -led coalition of environmental organizations and activists faced intense police repression, with many suffering lifelong injuries.

[2]We choose to use both "bison" and "buffalo" to acknowledge the kin relations between many tribal nations and buffalo, alongside the western scientific nomenclature. See Wind River Tribal Buffalo Initiative for an example. We also acknowledge that both are in the colonial language of English, and that the terms for these beings in Indigenous languages likely better reflect these complexities.

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