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De-extinction and the risk of moral hazard

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ABSTRACT

Moral hazard occurs when the presence or promise of a new technology or policy reduces incentives for responsible behaviour, because the consequences of risky behaviour are perceived to be reduced, transferred, or mitigated. Moral hazard risk has been widely empirically investigated in the case of geoengineering for climate change, but other novel technologies have not been subject to such scrutiny. Ever since de-extinction was announced to the public as a viable possibility with modern biotechnology, a series of commentators have argued that the promise of de-extinction will create a moral hazard. The thought is that extinction has been perceived as permanent. Any change in this belief, such as the idea that species can be brought back, potentially undermines the motivation for current conservation efforts. This is an empirical claim that we investigate. Our study assesses the public's support for conservation in scenarios that promise the use of de-extinction to address actions that are likely to cause extinction. We did not find that people were more likely to accept the extinction of a species if its de-extinction was promised in the future. We did, however, find an association between extinction acceptance and judgments that de-extinction could successfully resurrect species. The findings of this study represent a crucial step in assessing the risks novel biotechnology creates.

1. Introduction

On April 7, 2025, Colossal Biosciences announced that it had resurrected the dire wolf, a megafauna-hunting wolf species that had been extinct for 10,000 years. The "de-extinction" of this species was claimed on the grounds that the company had engineered 20 edits in 14 genes identified from dire wolf remains into gray wolves. Within 2 days, the Interior Secretary of the United States of America used the claimed resurrection of the dire wolf as a reason to justify the weakening of environmental protection laws, stating: "pick your favorite species and call up Colossal" and "You want dodos? Let's bring them back. You want kiwis? Bring them back" (Zwarenstein, 2025). This reasoning appeared to confirm predictions made by critics of de-extinction. Since public announcements about the possibility of de-extinction emerged in a series of TED talks in 2013, critics have argued that "de-extinction" or even communication about "de-extinction" could undermine support for conservation of existing species; that de-extinction creates a moral hazard risk (Sherkow and Greely, 2013; Redford et al., 2013; Pimm, 2013; Turner, 2014; Seddon et al., 2014; Sandler, 2014; Minteer, 2015; Rohwer and Marris, 2018; Lean, 2020; Katz, 2022; Lean, 2022; Odenbaugh, 2023).

Moral hazard is a significant risk associated with deploying new technologies. We use the following definition of moral hazard: *a moral hazard occurs when the presence or promise of a new technology or policy reduces incentives for responsible behaviour, because the consequences of risky behaviour are perceived to be reduced, transferred, or mitigated by the new technology* (Reynolds, 2015). For example, using biotechnology to address environmental degradation is recognised as risking moral hazard because it shifts costs away from the degraders (Redford et al., 2013; Lean, 2024). De-extinction is a potentially potent source of moral hazard because it seemingly undermines a core message of conservation, namely that extinction is irreversible. Most conservationists argue that species should be preserved, regardless of their apparent utility, because once gone, they can never come back, and we lose any possible current or future uses or valuations of them. If de-extinction is possible, this justification for investing in preservation is undermined.[1]

Moral hazard is a hypothesis about human psychology. Regarding de-extinction, the moral hazard is that if this technology is introduced,

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[1] Actual possibility is not necessary for a moral hazard to exist; all that is necessary is for enough relevant individuals or institutions to believe it is possible, so that they change their behaviour.

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then people will reduce their commitment to conservation, as extinction will no longer be irreversible. However, this hypothesis about human psychology cannot just be postulated; it must be researched (Lean and Lynch, 2023). To date, limited publicly available research has investigated lay and expert perceptions of de-extinction. Valdez et al. (2019) found that 43 % of expert respondents expressed concerns about the impact of de-extinction on current conservation efforts. Similarly, mixed results were found in a survey of conservation experts in New Zealand, with 40 % supporting de-extinction and 35 % opposing it (Taylor et al., 2017). These studies focus on attitudes towards or concerns about de-extinction, but do not investigate moral hazard per se, i.e. whether de-extinction alters people's commitment to conservation.

This study primarily investigates the public's response to one method of de-extinction in which a species related to the extinct species is genetically modified to introduce genes identified within the extinct species. Alternative approaches to de-extinction include the selective 'backbreeding' of features from an extinct species found in a related species into a single lineage, and the cloning of an extinct species. Each of these technologies carries different meanings of 'de-extinction'. Genomic modification de-extinction may be considered an induced speciation event, but there is a consensus that this technology does not recreate the extinct species (e.g. Siipi and Finkelman, 2017; Finkelman, 2018; Seddon and King, 2019), although, as with back-breeding, the resulting creatures may fill an important ecological role (Seddon et al., 2014). In contrast, cloning can be used to directly restore extinct diversity to extant lineages to revive a species that was previously near extinction, such as occurred with the black-footed ferret (Wisely et al., 2015). If enough diverse individuals could be cloned from an extinct population, it could be argued that a true de-extinction is possible. Here we focus on genomic modification de-extinction as it is both rapidly developing in the public sphere, and there is little information on how the public interprets the technology.

This study investigates individuals' psychological commitments to preventing extinctions in circumstances where de-extinction is proposed to rectify species loss. In structure, our study shares similarities with climate research investigating whether geoengineering to remediate atmospheric carbon reduces people's psychological commitment to reducing carbon emissions. Our findings are consistent with geoengineering studies, in that we did not find evidence of moral hazard created by de-extinction technologies. However, we did find evidence of an association between judging that a species could be successfully recreated and morally hazardous beliefs. Given that extinct species cannot be successfully recreated with their original features intact using genomic modification de-extinction, our findings suggest that more nuance is required in communicating the apparent success of this technology.

2. Geoengineering and moral hazard

Concerns about moral hazard have been prevalent in the literature regarding the development of geoengineering (e.g. stratospheric sulphate injection) and Carbon Capture and Storage (CCS) technologies for addressing climate change (e.g. Gardiner, 2006, 2011; Hale, 2009, 2012; Preston, 2011). These concerns motivated empirical investigations into geoengineering, stimulating significant research over the last 15 years into whether the development of this technology will impact public commitment to reducing emissions.

While research methods have varied, there is a growing consensus that informing people about the possibility of geoengineering solutions leads to *increased* efforts at mitigation, i.e. there is no moral hazard (Cherry et al., 2023). Current findings indicate that the public will not change its preferences for emission reduction under circumstances where carbon sequestration is developed (Corner and Pidgeon, 2010; Braman et al., 2012; Merk et al., 2015; Merk et al., 2016; Hart et al., 2022; Andrews et al., 2022; Schoenegger and Mintz-Woo, 2024). Much of the research has relied on individual responses to surveys about hypothetical scenarios (Merk et al., 2016). More recently, research using economic games has tested citizens' responses to policy decisions about deploying geoengineering (Andrews et al., 2022), finding that citizens supported mitigation strategies even if geoengineering were deployed, with Cherry et al. (2023) finding that the availability of geoengineering led to greater mitigation effects.

However, some studies do indicate moral hazard effects or risks. Campbell-Arvai et al. (2017) found that being informed about certain carbon dioxide removal strategies indirectly reduced support for mitigation policies by reducing the perceived threat of climate change. Further, lay people appear to be concerned that the development of technologies capable of sequestering carbon from the atmosphere would lead to a decreased commitment to reducing emissions, either among others or governments (e.g. Macnaghten and Szerszynski, 2013; Andrews et al., 2022). The anticipated moral hazard results, however, have been less robust than the 'reverse moral hazard' results that show increased commitment to mitigation efforts in the face of geoengineering (Fairbrother, 2016; Merk et al., 2016; Austin and Converse, 2021; Cherry et al., 2021; Reynolds, 2019). Perhaps the drastic nature of these interventions makes salient the grave need to arrest climate change.

The findings of research into moral hazard and geoengineering suggest that we should exercise caution when raising concerns about the risk of moral hazard, as overemphasising this risk (moral hazard anticipation) may undermine the deployment of technologies that could potentially support remediation efforts (Andrews et al., 2022). Moral hazard anticipation (i.e. concern that citizens will engage in moral hazard) may lead policy makers to avoid potentially effective technologies, just in case their use decreases citizens' efforts at and support for mitigation strategies (Andrews et al., 2022). This could be counterproductive given that the technology might be safe and effective with significant climate change impacts, and the threat of its use might trigger increased mitigation efforts by citizens. Thus, stalling geoengineering research and reducing the scope of its effective deployment due to moral hazard anticipation would be unwise. De-extinction shares similarities with geoengineering in that it may trigger moral hazard anticipation by policymakers, thereby reducing any potential significant positive effects on the environment from the long-term development of this technology. In addition, claiming that de-extinction risks moral hazard without empirically investigating the possibility attributes a type of moral failing to the public without evidence.

Our study follows the geoengineering literature in investigating public responses to de-extinction. We pose hypothetical scenarios where a large project will cause the extinction of a species. We investigate whether the possibility of de-extinction leads to support either for causing this extinction or for further projects that could cause extinctions. Our results provide crucial evidence on whether the possibility of de-extinction projects could foster reduced commitment to conservation.

3. Methodology

In this study, we investigated whether people exhibit moral hazard in response to de-extinction technology. We compared participants' judgments about their commitment to preventing extinctions between cases where de-extinction is proposed to rectify species loss and cases where further conservation of other species is proposed. We did this using two threatened species: the dusky gopher frog and salt marsh harvest mouse. These cases are presented as trade-offs, in which large infrastructure projects are proposed as the justification for causing the extinction, and general environmental investment or de-extinction are presented as compensation for the species loss. This format allows us to investigate the effect of proposing de-extinction as a novel form of environmental compensation.

4. Participants

375 US residents were recruited and tested online using Prolific (https://www.prolific.com). Prolific is a participant recruitment platform for online research and has been previously used successfully for research investigating moral hazard risk with geoengineering (e.g. Schoenegger and Mintz-Woo, 2024). Potential participants are pre-vetted, and the resulting samples are more demographically representative than typical samples of convenience (i.e. the university classroom).

Participants responded to the study title "A study about species conservation". They were informed that the study involved the completion of a brief two-part questionnaire. In part one, they would be asked their views about the conservation of a threatened species. In part two, they would be asked a few demographic questions about themselves. No mention of de-extinction was made before the study commenced. Participants were warned not to participate if reading about species extinction might result in them feeling anxious or distressed. As participation is self-selected, this might introduce certain biases into the results that we present next. We will return to reflect on this and other limitations later in the section Recommendations and future directions.

Twelve participants were excluded from the analyses for failing to respond to all the questions or answer all the attention and comprehension checks correctly. Participants failed an attention check if they (i) responded when explicitly asked to leave the response box blank or (ii) failed to correctly respond to a CAPTCHA. Participants failed a comprehension check if they (i) incorrectly identified the species threatened with extinction in the vignette, (ii) incorrectly identified the infrastructure project that threatened the species, or (iii) incorrectly identified what was being proposed to make up for the extinction of the threatened species.

The final sample consisted of 363 participants (176 male, 184 female, 3 trans/non-binary; 225 White/European, 6 Native American/American Indian, 11 Multi-Racial/Mixed Heritage, 9 Hispanic/Latino, 105 Black/African American, 6 Asian/Pacific Islander, 1 Other; aged 18–78, $M = 38.09$, $SD = 12.81$). Politically, the sample was roughly balanced (45.7 % conservative, 17.4 % moderate, 36.9 % liberal). Ethics approval for the study was obtained from the Aarhus University Human Research Ethics Committee.[2]

5. Materials and procedure

The study was a 2 × 2 Between-Subjects design. The 4 conditions included every combination of de-extinction proposed vs conservation proposed, and dusky gopher frog vs salt marsh harvest mouse. Participants were randomly assigned to evaluate one of the four vignette conditions. All four possible vignettes are reproduced below in Table 1.

Following the vignette, participants were asked to respond to several statements. Participants could indicate their level of agreement with each statement on a 7-point Likert scale that ranged between "strongly disagree" and "strongly agree". 7-point Likert scales were chosen as they afford participants the ability to provide a graded or midpoint response. Moral hazard risk would appear to admit degrees, and this is something that we wished to be able to capture. The exact wording of each statement varied according to whether the condition they were assigned to described the (i) dusky gopher frog or salt marsh harvest mouse and (ii) described the companies' proposed conservation or de-extinction efforts. The full set of statements is reproduced below in Table 2.

Participants assigned to a de-extinction condition saw and responded to one additional statement,

De-Extinction Possible:

"Genetic Engineering could be successfully used to recreate the extinct Dusky Gopher Frog/Salt Marsh Harvest Mouse".

Here too, participants responded by indicating their level of agreement on a 7-point Likert scale ranging between "strongly disagree" and "strongly agree". Statement order and response scale orientation were randomized across participants.

6. Results

Overall, we found no evidence that proposing to use de-extinction technology had any influence on participants' judgments to any of the statements that we examined. That is, we found no evidence of a moral hazard associated with the proposed use of de-extinction technology to rectify a species loss. However, in de-extinction conditions, we did find significant associations between participants' judgments about the success of de-extinction technology and their other judgments. The more people agreed that de-extinction technology could be successfully used, the more morally hazardous their judgments.

Table 3 below summarises the descriptive results for participants' levels of agreement to each statement in dusky gopher frog conditions. Results from the conservation condition are on the left side of the table while results from the de-extinction condition are on the right. The % Agree column represents the proportion of participants who agreed with the statement (5, 6, 7 on the Likert scale). The %Disagree column represents the proportion of participants who disagreed with the statement (1, 2, 3). The %4 column represents the proportion of people who were indifferent.

Table 4 below summarises the descriptive results for participants' levels of agreement with each statement in salt marsh harvest mouse conditions. The table is organised in the same fashion as Table 3.

Participants' levels of agreement to each statement (except "De-extinction Possible") were examined using separate 2 (de-extinction proposed; conservation proposed) × 2 (dusky gopher frog; salt marsh harvest mouse) between-subjects ANOVAs. ANOVAs examining "Extinction is Bad", "Extinction Justified", "Restitution", "Restitution (General)", "Extinction Justified (General)", and "Moral Risk" all failed to find any evidence of any significant effects. That is, there was no evidence that people's judgments were influenced by the intervention or species in question.[3]

Next, for de-extinction conditions, we examined the association between participants' level of agreement that de-extinction is possible and other judgments by calculating separate Spearman Rho correlation coefficients. Table 5 below displays the coefficient values.

In the dusky gopher frog case there was a medium[4] positive association between participants' "De-extinction Possible" judgments and their "Extinction Justified" and "Restitution" judgments, and a large positive association with their "Restitution (General)" and "Extinction Justified (General)" judgments. In the salt marsh harvest mouse case, there was a large positive association between participants' "De-extinction Possible" judgments and their "Extinction Justified" and "Restitution" judgments, and medium positive association with their "Restitution (General)" and "Extinction Justified (General)" judgments. That is, the more participants agreed that de-extinction technology could recreate the same species, the more they also tended to judge that extinction was justified, that de-extinction would make the company and us less blameworthy, and that de-extinction could justify causing

[2] Our reported results (or lack thereof) do not change when we rerun analyses with the inclusion of participant demographics (gender, age, ethnicity, and political ideology) as covariates.

[3] The only exception was an interaction effect between proposed intervention and species on "Project is Good" judgments, $F(1, 359) = 4.299$, $p = .039$. However, judgments about how good a project would be, provided they are accurate, are not associated with any moral hazard.

[4] Here we follow conventions suggested by Cohen (1988) for interpreting the magnitude of a correlation in the behavioural sciences: small = 0.1, medium = 0.3, and large = 0.5.

Table 1
Study vignettes.

Dusky Gopher Frog Conservation	Salt Marsh Harvest Mouse Conservation
The Southern Mississippi Development Company is building a new port in the area with a connecting highway. The developer says the project will benefit the region by creating jobs and funding schools. However, building the highway will threaten the Dusky Gopher Frog, which is an endangered species. The Dusky Gopher Frogs live in burrows by ponds. The highway will pass through the frogs' last two breeding ponds. As a result, the project will cause the extinction of the Dusky Gopher Frog. To make up for the extinction of the Dusky Gopher Frog, the Southern Mississippi Development Company will invest in other Southern Mississippi ecosystems to support the conservation of different threatened species.	The Salt Marsh Harvest Mouse is native to the San Francisco Bay's marshlands. It lives in tidal marshes and eats pickleweed and salt grass. This species is unique, as most mammals avoid salty environments. The last remaining Salt Marsh Harvest Mouse habitat is outside of San Francisco. This land is planned to be used for a desalinisation plant (which produces fresh water from salt water) attached to a large Artificial Intelligence (AI) server centre. Artificial Intelligence servers use over a quarter of a gallon of water per 100 questions people ask of it, requiring millions of gallons of water a day to provide people access to AI on their phones and computers. This large centre, built near America's tech hub, would help American businesses and provide more people with access to AI. Reclaiming the land will cause the extinction of the Salt Harvest Mouse. To make up for the extinction of the Salt Marsh Harvest Mouse, AI companies will invest in other Californian ecosystems to support the conservation of different threatened species.
Dusky Gopher Frog De-Extinction	**Salt Marsh Harvest Mouse De-Extinction**
The Southern Mississippi Development Company is building a new port in the area with a connecting highway. The developer says the project will benefit the region by creating jobs and funding schools. However, building the highway will threaten the Dusky Gopher Frog, which is an endangered species. The Dusky Gopher Frogs live in burrows by ponds. The highway will pass through the frogs' last two breeding ponds. As a result, the project will cause the extinction of the Dusky Gopher Frog. To make up for the extinction of the Frog, the Southern Mississippi Development Company will recreate the species after its extinction. Scientists will collect the frog's genetic material (DNA) and store it. The DNA will later be put into a closely related frog species to make a new version of the Dusky Gopher Frog. If successful, the newly recreated Dusky Gopher Frog will be released into a new habitat 60 miles away.	The Salt Marsh Harvest Mouse is native to the San Francisco Bay's marshlands. It lives in tidal marshes and eats pickleweed and salt grass. This species is unique, as most mammals avoid salty environments. The last remaining Salt Marsh Harvest Mouse habitat is outside of San Francisco. This land is planned to be used for a desalinisation plant (which produces fresh water from salt water) attached to a large Artificial Intelligence (AI) server centre. Artificial Intelligence servers use over a quarter of a gallon of water per 100 questions people ask of it, requiring millions of gallons of water a day to provide people access to AI on their phones and computers. This large centre, built near America's tech hub, would help American businesses and provide more people with access to AI. Reclaiming the land will cause the extinction of the Salt Harvest Mouse. To make up for the extinction of the Salt Harvest Mouse, the AI companies will recreate the species after its extinction. Scientists will collect the mouse's genetic material (DNA) and store it. The DNA will later be put into a closely related mouse species to make a new version of the Salt Harvest Mouse. If successful, the newly recreated Salt Harvest Mouse will be released into a new habitat in Northern California, away from cities.

Table 2
Study statements.

Extinction is Bad
"It would be bad if the Dusky Gopher Frog/Salt Marsh Harvest Mouse went extinct as a result of building the new port and connecting highway/desalinisation plant".
Project is Good
"Building the new port and connecting highway/desalinisation plant would be good for the public in Southern Mississippi/people and American businesses".
Extinction Justified
"The good provided by the new port and connecting highway to the public in Southern Mississippi/desalinisation plant to people and American business is greater than the badness of its construction causing the Dusky Gopher Frog/Salt Marsh Harvest Mouse to go extinct".
Restitution
"Investing in the conservation of Southern Mississippi/other Californian ecosystems would make the Southern Mississippi Development Company/AI companies less blameworthy for causing the extinction of the Dusky Gopher Frog/Salt Marsh Harvest Mouse".
"Recreating the Dusky Gopher Frog would make the Southern Mississippi Development Company less blameworthy for causing its extinction".
Restitution (General)
"Investing in conservation makes us less blameworthy for causing species extinctions".
"Recreating species makes us less blameworthy for causing species extinctions".
Extinction Justified (General)
"Causing the extinction of one highly endangered species would be justified so long as we protected several other threatened species".
"Causing the extinction of a highly endangered species would be justified so long as we recreate and reintroduce them back into the wild at a later time".
Moral Risk
"If causing species extinctions also results in us protecting several other threatened species, then it would be acceptable to carry out more projects that cause species extinctions".
"If extinct species can be recreated and successfully reintroduced back to the wild, then it would be acceptable to carry out more projects that cause species extinctions".

extinction.

There was also a positive association between participants' "De-extinction Possible" judgments and their "Project is Good" and "Moral Risk" (See Fig. 1) judgments. These associations were small and medium in the dusky gopher frog case, and large and medium in the salt marsh harvest mouse case. That is, the more participants agreed that de-extinction technology could be successfully used, the more they also tended to judge that the project was good, and that if de-extinction was possible, then it would be permissible to cause future species extinctions.

Finally, in the dusky gopher frog condition, there was a medium negative association between participants' "De-extinction possible" judgments and their "Extinction is Bad" judgments. There was no evidence of any such association in the salt marsh harvest mouse condition. The more participants agreed that de-extinction technology could be successfully used, the less they tended to judge that extinction was bad, but only in the dusky gopher frog condition.

Table 3
Descriptive results of participants' judgments in dusky gopher frog conditions.

Statement	Conservation ($n = 91$)					De-Extinction ($n = 92$)				
	%Agree	%Disagree	%4	M	SD	%Agree	%Disagree	%4	M	SD
Extinction is Bad	76.9	11.0	12.1	5.56	1.53	68.5	16.3	15.2	5.28	1.67
Project is Good	79.1	11.0	9.9	5.37	1.34	81.5	6.5	12.0	5.49	1.38
Extinction Justified	36.2	42.9	20.9	3.82	1.76	36.9	45.7	17.4	3.83	1.80
Restitution	37.3	44.0	18.7	3.76	1.84	33.7	46.7	19.6	3.68	1.87
Restitution (General)	37.4	50.5	12.1	3.68	1.97	32.6	56.5	10.9	3.41	1.85
Extinction Justified (General)	27.5	53.8	18.7	3.25	1.86	29.3	60.9	9.8	3.18	1.86
Moral Risk	28.6	53.8	17.6	3.11	1.82	19.5	62.0	18.5	3.05	1.82
De-extinction Possible	–	–	–	–	–	52.2	26.1	21.7	4.47	1.69

Table 4
Descriptive results of participants' judgments in salt marsh harvest mouse conditions.

Statement	Conservation ($n = 88$)					De-Extinction (n = 92)				
	%Agree	%Disagree	%4	M	SD	%Agree	%Disagree	%4	M	SD
Extinction is Bad	77.3	17.0	5.7	5.56	1.65	75.0	14.1	10.9	5.47	1.62
Project is Good	80.6	11.4	8.0	5.51	1.43	61.9	17.4	20.7	5.00	1.60
Extinction Justified	28.5	42.0	29.5	3.65	1.70	37.0	38.0	25.0	4.03	1.74
Restitution	30.7	51.1	18.2	3.55	1.85	32.6	47.8	19.6	3.68	1.81
Restitution (General)	32.9	58.0	9.1	3.42	1.86	27.1	53.3	19.6	3.43	1.78
Extinction Justified (General)	17.1	67.0	15.9	2.88	1.67	28.3	57.6	14.1	3.21	1.84
Moral Risk	26.1	61.4	12.5	2.95	1.79	32.7	54.3	13.0	3.33	2.05
De-extinction Possible	–	–	–	–	–	63.0	19.6	17.4	4.74	1.60

Table 5
Spearman Rho correlation coefficients between participants' "De-extinction is Possible" judgment and other judgments in De-extinction conditions.

	Extinction is Bad	Project is Good	Extinction Justified	Restitution	Restitution (General)	Extinction Justified (General)	Moral Risk
Dusky Gopher Frog	−0.32*	0.25*	0.46**	0.47**	0.50**	0.53**	0.45**
Salt Marsh Harvest Mouse	−0.09	0.67**	0.63**	0.50**	0.45**	0.49**	0.32*

** $p < .001$.
* $.001 \leq p \leq .05$.

7. Discussion

We found that the suggested deployment of de-extinction technology does not increase acceptance of extinction in either vignette. That is, there was no indication that the possibility of de-extinction reduced the respondents' commitment to conservation. This will be heartening to many within conservation who both support and critique de-extinction. This finding is consistent with the geoengineering literature, where technological interventions do not appear to diminish support for addressing anthropogenic environmental damage.

It is slightly disconcerting that between 20 % and 40 % of respondents thought that causing extinction is justified in both vignettes, on the basis that the public good of the projects is greater than the bad of the extinction of either species. This suggests that a significant proportion of the population regards the value of species as inferior to the value of public infrastructure in general, irrespective of conservation and de-extinction technologies. Given this finding, theoretical and political efforts to cultivate public sentiment towards valuing species and ecosystem diversity are warranted.

Respondents' preferences did not lean towards more environmentally risky behaviour (i.e. permitting extinction) when de-extinction was suggested relative to the control condition, i.e. we did not detect any moral hazard. One possible reason for this is that people oppose extinction and view it as morally wrong, regardless of mitigation or compensatory efforts. If extinction is seen as intrinsically wrong regardless of mitigation, this could explain the absence of moral hazard. This interpretation potentially supports the narrative that de-extinction extends conservation techniques rather than undermining or competing with them. These findings are, however, local to a specific cultural audience. How species are ascribed relative value in moral reasoning may vary cross-culturally, as would the acceptance of biotechnological intervention into the natural environment more generally.

The apparent lack of an effect may also be affected by the propensity of respondents towards either moral absolutism or moral pragmatism. Because each scenario is presented as a trade-off, there may be a proportion of respondents who, as moral absolutists (whether in the case of extinction or more broadly) will not change their preferences irrespective of the circumstances of extinction. If so, the 20 % to 40 % who do accept a trade-off over infrastructure are likely to be pragmatic about species loss when both forms of compensation are offered. Further, there may be a portion of the population who would accept extinction if the compensation were higher in the scenarios. The proportion of those who are moral absolutists and those who are more pragmatic will likely vary across cultures. Additionally, it is possible that the degree to which respondents are inclined towards pragmatism may change according to the details of a given trade-off scenario, as well as their own proximity to a given scenario.

There are multiple explanations that could account for the apparent lack of moral hazard in our results. Exploring these is a task for future research into moral hazard risk and de-extinction. Nonetheless, alternative reasons suggested in the geoengineering literature may be relevant in the context of environmental biotechnology (e.g. Merk et al., 2016). First, for people to be willing to increase risky behaviour, they need to be confident that the technology will be successful. People are aware that the effective implementation of new technology could take time and is unlikely to be immediately effective, or they may assume that any implementation of de-extinction technology is unlikely to succeed. Second, some populations may be opposed to de-extinction technologies due to public health and safety concerns, even if the technology is possible and effective. Equally, given the structure of the

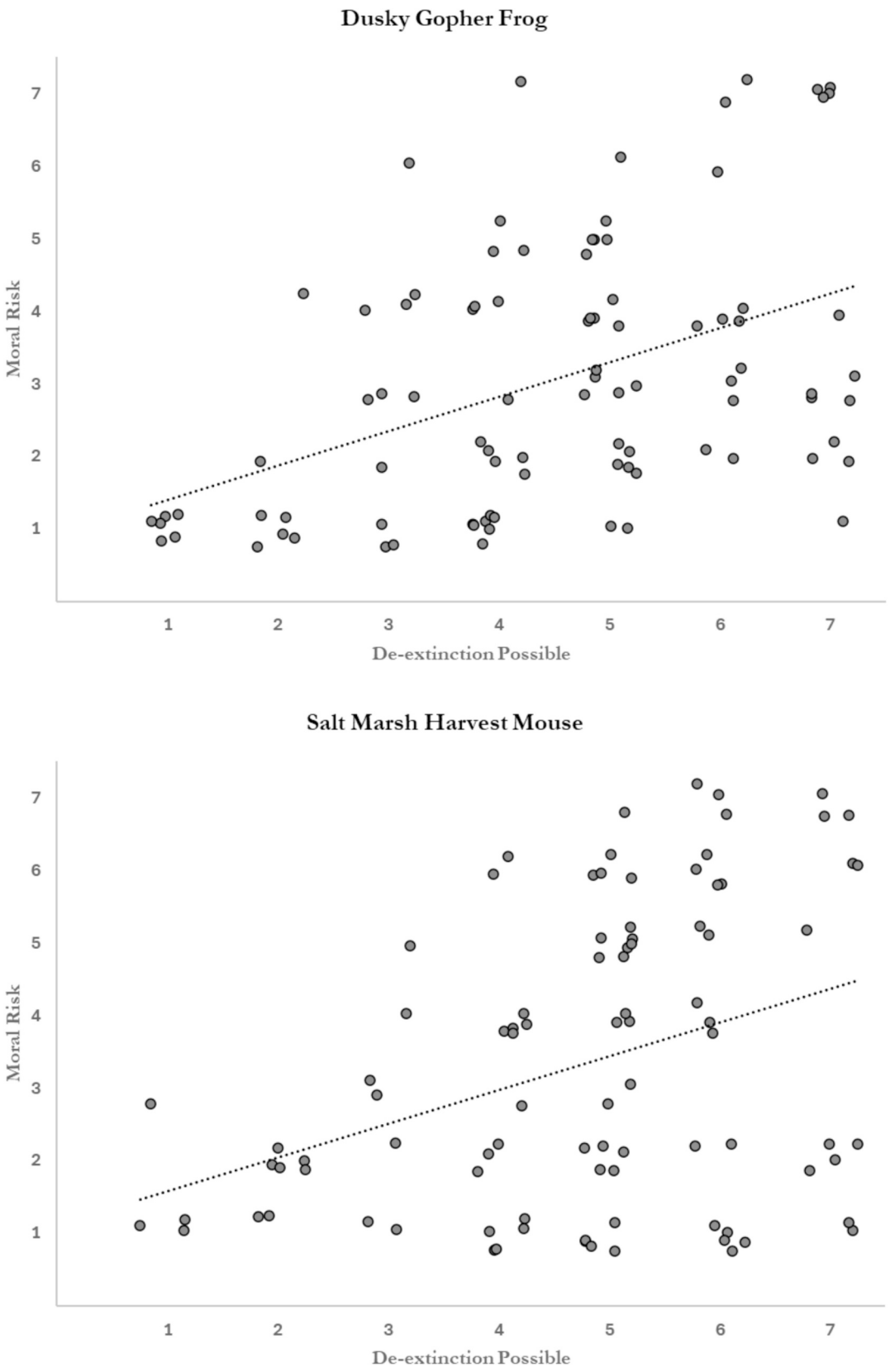

Fig. 1. Jitter plots showing participants' "De-extinction Possible" judgments by "Moral Risk" judgments in dusky gopher frog ($\rho = 0.45$) and salt marsh harvest mouse ($\rho = 0.32$) conditions.

vignettes, they may believe that the companies are untrustworthy and will not fulfil their promise to invest in either conservation or de-extinction once the project is accepted.

Further, the drastic, expensive, and technically challenging nature of interventions such as de-extinction or geoengineering could make the environmental damage more salient. Particularly in the case of geoengineering, this seems like a relevant possibility due to the inverse 'negative moral hazard' effects that have been discovered (Reynolds, 2019). In the case of de-extinction, the costs and effort cited may evoke a similar recognition of the severity of extinction and the effort required to overcome the loss of a species, as opposed to preserving it.

Finally, some respondents may oppose the technology itself and seek to counter its deployment by maintaining or strengthening existing environmental protection efforts. In both geoengineering and de-extinction, such opposition may be driven by discomfort with humanity undertaking drastic interventions in nature, often described as 'playing God.' This phrase can capture a range of concerns, including both the potential consequences of using a technology and objections to the act of using it at all ("an intrinsic objection") (Carter et al., 2021). These concerns may reflect fears of hubris, unpredictable risks, or mistrust in the concentration of power among those able to implement such technologies. There are principled reasons why people may have intrinsic objections to significant genomic re-design of organisms, which may disrupt deep historical relationships (Preston, 2014). Some critics of using biotechnology to address the environmental crisis argue against technological solutions, largely on the basis that technological advancement has been a cause of ecosystem disruption, including species extinction (Carton et al., 2017). These critics favour measures for environmental protection, and the public may harbour similar views. There are many reasons why people may experience discomfort or object to new technology, which could influence their reluctance to rely on it.

If people are steadfast in their opposition to extinction because they believe it is morally wrong, and de-extinction does not affect this belief, this could translate into or be understood as support for the technology. De-extinction could then be seen, as claimed by its advocates, as additional to conservation. Anticipating how the technology is to be represented and understood will be a challenge for obtaining social licence, given the various reasons outlined why people may not change their opposition to extinction. Further research will be required to identify whether the lack of moral hazard we identified was due to a steadfast moral preference against extinction or an ethical judgment against the technology. Another avenue of enquiry is further research on the portion of the sample (between 20 and 40 %) who believed that extinction was justified on the basis that the public good of the infrastructure exceeded the bad of extinction. Hesitance towards de-extinction technologies may be less about moral wrong or right, and more about overall costs versus benefits.

While de-extinction had no effect on preferences for species conservation, a significant finding emerged within the de-extinction cases. There was an association between the belief that causing extinction in the presented scenario was permissible and the belief that de-extinction could resurrect that extinct species. This appears to be a moral hazard-style reasoning to justify extinction, where belief in resurrection causes an increased acceptance of extinction. This association, however, did not affect the degree to which people in the de-extinction scenario accepted extinction over the control population in our study.

One potential reason for this association could be that believing that de-extinction is possible is a somewhat self-serving belief to justify an existing view that extinction is permissible. This would reflect participants' creating excusatory reasons for permitting or causing extinction. If these people were always going to accept the extinction of species, this reasoning would not cause a moral hazard. Similar reasoning may apply to the Interior Secretary of the USA, who has shown no interest in protecting species. It is potentially worrying for many conservationists that de-extinction may function as an excuse for people who would wilfully cause extinctions. If these excuses could be used to circumvent opposition to extinction, there is a significant risk attached to them.

A different interpretation of this finding is that some respondents reason that if de-extinction is successful, then extinction is (or might be) justified. This reasoning could create a moral hazard. In our study, among those participants who judged that de-extinction would *not* be possible or were unsure, only 16.7 % judged that causing the species' extinction would be justified, whereas 83.3 % judged that it would not be justified. However, participants who judged that de-extinction would be possible were divided as to whether causing the extinction would be justified; 51.9 % said that it would be, and 48.1 % said that it would not. If this inference were to become more widespread among the public, it would create a moral hazard effect. This could happen if de-extinction gains more public attention and is perceived to be successful at resurrecting extinct species. If de-extinction companies continue to represent their engineered organisms as being the same species as the extinct species, this may increase the acceptability of extinction.

However, as mentioned above, there is a strong view that genomic modification does not recreate an extinct species (e.g. Siipi and Finkelman, 2017; Finkelman, 2018; Seddon and King, 2019). Rather, the current products of de-extinction are extant species modified with genomic material from extinct species. On nearly all species concepts, the modified individuals are either part of the extant species or an induced speciation event. This is despite an attempt by individuals within the de-extinction community to invoke a morphological species concept, claiming that if the recreated organism is morphologically similar to the extinct population, then it is the same species. The morphological species concept has, however, been largely rejected in the biological sciences for many decades, other than perhaps for microorganisms, where significant lateral gene transfer complicates lineages, and in palaeontology, where genetic data is not available (Simpson, 1961). This is because morphology is largely in the eye of the beholder and lacks rigor compared to most other species concepts, which define species through lineages. The advent of genetic data has shown the incredible abundance of cryptic species that are not easily discernible to human observation (Bickford et al., 2007). At best, proponents of de-extinction could claim that de-extinction is a hybridisation event with a temporal gap. But in cases where only 20 edits in 14 genes are made (i.e. the "dire wolf"), this is implausible. Recreating the extinct species is, however, not necessary for de-extinction to be of conservation value (Lean, 2020). The creation of ecological proxies for the extinct population can arguably allow for ecosystem restoration and the support of other endangered populations, and the technology created through de-extinction research could be reapplied for protecting endangered species.[5]

In our study, many participants judged that de-extinction technology could *not* be successfully used. But why? One possibility, as just discussed, is that some lay people too reject (perhaps only tacitly) the morphological species concept. That is, they may believe that there is nothing wrong with the technology, and it could be successfully used to engineer something that is very similar to the target extinct species. Further, the engineered species might be judged to be valuable. But it is *not* the same as the extinct species, and so the technology could not be used to recreate an extinct species. Alternatively, some people may hold a standing scepticism towards the possibility of de-extinction technology, even if they believe that using de-extinction technology to successfully engineer a species that was very similar to a target extinct species would recreate it. But believing that such technology is not possible (perhaps just at this time) means that successful de-extinction is not possible either. Future research is needed to clarify the different reasons people reject the possibility of successful de-extinction technology.

This complexity illustrates why clear communication around de-

[5] See Ronald Sandler's comments for a similar perspective (Stening, 2025).

extinction is so important. In the wake of the dire wolf announcement, there were immediately many voices that pushed Colossal to concede that the wolves were modified gray wolves rather than dire wolves (e.g. Coyne, 2025; Bolotnikova, 2025). This forced the concession from Beth Shapiro in an interview with New Scientist, published on the 24th of May, that "It's not possible to bring something back that is identical to a species that used to be alive. Our animals are grey wolves with 20 edits that are cloned." "And we've said that from the very beginning. Colloquially, they're calling them dire wolves and that makes people angry." (Le Page, 2025). However, in her interview published on the 18th of June on The Joe Rogan Podcast, a much larger audience than the New Scientist, she repeatedly referred to the pups as dire wolves, stating "they are dire wolves as we have manipulated the DNA of gray wolves" (Rogan, 2025).

Clear communication is possible, as shown by other de-extinction projects. The back-breeding Tauros project has been working to create an approximation of an Auroch. This is being done through the selective breeding of remnant Auroch traits, still found in various cattle populations, into a single cattle lineage. This selectively bred population is described by the Tauros project as Auroch 2.0. The primary focus communicated to the public is the development of an ecological proxy for the Auroch to aid in ecosystem restoration (Jepson, 2025). Organisms created through genomic modifications could also be identified by their functional role in conservation and accepted as proxies. Ultimately, we believe that the consistent communication of the identity and justification for these modified organisms will be crucial for their ethical deployment.

8. Recommendations and future directions

- ➢ We caution against a strong rejection of de-extinction. We did not find any effect on conservation commitments in response to the suggestion of compensating for environmental damage with de-extinction. This is consistent with the moral hazard literature in geoengineering.
  - There is a risk in overemphasising moral hazard (Andrews et al., 2022). Therefore, caution is necessary when recommending against the use of this technology on these grounds. It could stall the development of effective techniques and potentially important uses that will aid conservation in the future.
- ➢ We recommend against claims that the organisms altered to include the DNA of extinct lineages are recreations of (the same as) the extinct species. Audience beliefs that extinct species can be resurrected may reduce perceived risks and be seen to justify causing extinction.
  - Explaining that these are partial restorations of the genetic diversity of these lost lineages moves towards the truth that these creations could have utility, while acknowledging that it is not possible to bring back all the features of a species lost through extinction.
  - The technology, when used on species that are not extinct, is unlikely to have this risk. There are many reasons to prefer the resurrection of individuals in a threatened species (primarily the likelihood of effectiveness).
- ➢ These findings are preliminary. Further social science research is necessary. Such research should be conducted as part of standard Responsible Research and Innovation (RRI) engagement before the deployment of these technologies.
  - In our study, we only looked at English speakers from the US, which could limit the generalizability of our findings. Future research should include more diverse groups and investigate the possibility of there being cross-cultural differences.
  - Cross-cultural or community-led research could also provide an understanding of how proximity to a given scenario of de-extinction may influence individual and subgroup propensity towards pragmatism, as well as provide a means of examining the influence of perceived realism of given scenarios. Different population subgroups could also be identified using more complex analysis methods, such as latent class analysis and regression modelling.
  - Further research is needed on the public perception of the 'de-extinct' organisms created through genomic modification, including how familiar they are with the methods, how they interpret species identity and its significance, and whether they view these products as being the same species.
  - People's judgments might have been influenced by how realistic they found the vignettes. Specifically, it might have appeared strange to some that the same group developing the infrastructure was also performing the de-extinction. Unrealistic scenarios might be treated differently by people and mask their actual judgments. It will be important to account for how realistic people find different vignettes in future research.

9. Conclusion

It has long been hypothesised that de-extinction could create a moral hazard by increasing the acceptance of extinction. This study is the first empirical investigation of whether the promise of de-extinction will create a moral hazard. We did not find any indication that the public views extinction as more acceptable if there are efforts to then recreate that species through de-extinction. Our findings are largely consistent with the studies of whether geoengineering or carbon sequestration technologies will encourage people to curb their carbon mitigation efforts. We did, however, identify a correlation between the views that extinction is justified and de-extinction involves the recreation of the lost species. This correlation could indicate a pernicious inference that needs to be accounted for in the communication of de-extinction innovations.

CRediT authorship contribution statement

Christopher H. Lean: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Andrew J. Latham:** Writing – original draft, Visualization, Validation, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Annie Sandrussi:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Wendy A. Rogers:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Impact statement

We found no evidence that de-extinction increases acceptance of extinction; however, we identified potential risks associated with the public communication of the technology.

Declaration of competing interest

None of the authors of this paper have any competing interests.

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Data availability

Data will be made available on request.

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