

Introduction to “Public Deliberation about Gene Editing in the Wild”

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Emerging technologies for the genetic modification of organisms present unprecedented opportunities to alter wild populations of organisms, from microbes to mammals, and consequently change interspecies dynamics and reshape ecosystems. With these opportunities come perplexing governance challenges. Most commentators maintain that decision-making about whether, when, and how to use these technologies should include public engagement activities, through which the public can learn about the science; researchers and their funders can learn about the public’s values; and final decisions can be shaped by a range of inputs. In its strongest form, the argument for public engagement holds that proceeding with a proposal to modify a wild population requires the public’s authorization. It is argued that where a project has a localized impact on a specific community, that community should be engaged in decisions about the project. But because many proposals to release genetically modified organisms into the wild may have practical and moral implications that reach far beyond any one community, some commentators call for public engagement to occur at a broader level, perhaps even nationally or internationally. In this view, broad public engagement with an opportunity for authorization is morally required because stewardship of the environment is a collective undertaking that involves high-stakes moral trade-offs and uncertainties.

Public engagement that is acceptable for, and capable of, substantively shaping decisions about the use of genetic technologies to modify wild organisms may require strategies for public *deliberation*—that is, for including the public in the reasoning that produces the decision instead of merely educating or polling the public. But how to legitimately and effectively engage in

broad public deliberation on these technologies is not clear. It is not clear how to decide on the kinds or categories of genetic modification proposals for which public deliberation is necessary or appropriate, and it is not clear how to carry it out when it is deemed appropriate. Much of the best-developed work on public deliberation has concerned issues in health policy that may have a tangible and personal impact on participants, where proposals are comparatively clearly specified, and relevant moral concerns are reasonably well recognized. By contrast, decisions about the use of genetic technologies to alter the shared environment may require public deliberative processes that can work for comparatively abstract proposals. Genetic modification proposals will sometimes present high-stakes risk, benefit, and uncertainty, and discussing them may bring out emotions or moral beliefs that are not easily debated or even articulated and whose relevance to public policy may be contested. Thus public deliberation may be particularly attractive for decisions about genetically modifying various organisms, but is also very much in question. Some of the prominent scholarly and public commentary on these decisions—from committees of the National Academies of Sciences, Engineering, and Medicine and from the Presidential Commission for the Study of Bioethical Issues, for example—has called for broader public deliberation, but deep questions remain about when and how to do it.

We draw on interdisciplinary scholarship in bioethics, political science, and public administration to move forward on this knot of conceptual, normative, and practical problems. When is broad public deliberation about gene editing in the wild necessary? And when it is required, how should it be done? These questions lead to a suite of further questions about, for example, the rationale and goals of deliberation, the features of these technologies that make public deliberation appropriate or inappropriate, the criteria by which “stakeholders” and “relevant publics” for these uses might be identified, how different approaches to public

deliberation map onto the challenges posed by the technologies, how the topic to be deliberated upon should be framed, and how the outcomes of public deliberation can be meaningfully connected to policy-making.

Motivations and Technologies to Modify Populations of Wild Organisms

Gene editing technologies have long been in use to modify domesticated nonhuman organisms. Work is now also under way to use them to modify nonhuman organisms in the shared environment, and through that to reshape ecosystems. Public health goals have been prominent in these proposals. For example, the *Aedes aegypti* mosquito transmits chikungunya, Dengue fever, and the Zika virus, and mosquitoes in the *Anopheles* complex transmit malaria. Genetic strategies to interrupt the transmission of these diseases could have an enormous public health impact. Agricultural goals include protecting crops from insect pests such as the diamondback moth, *Plutella xylostella*, which feeds on cabbage, broccoli, kale, and other crops, costing farmers around the world \$4-5 billion per year.¹ Genetically modified diamondback moths might reduce reliance on pesticides to control moth pests and increase crop yields. Mammalian pests and fungal, viral, and bacterial pathogens also threaten crop health and might be mitigated as well.

A third important set of goals are in environmental conservation. Some projects aim to protect populations of endangered fauna and flora. For example, the American chestnut has been largely driven to extinction by a fungal pathogen accidentally introduced into the United States in the twentieth century, and work under way to create a blight-resistant chestnut, either through cross-breeding with the resistant Asian chestnut or by genetically modifying a resistant American chestnut, could reestablish the chestnut and help restore Eastern U.S. forest ecosystems.² Genetic

modifications might also be used to weaken or attack organisms that threaten species. An example of the latter include techniques to eliminate invasive rodents that eat native plant seeds and seabird chicks and eggs in Hawaii and other islands.³ Yet other purportedly conservation-related proposals involve the recreation and reintroduction into the wild of extinct organisms, such as the bucardo (a subspecies of the Iberian ibex), the gastric-brooding frog, the wooly mammoth, and the passenger pigeon.

These goals can now be pursued through a variety of strategies. What might now be thought of as “conventional” genetic modification of wild populations involves the insertion of genetic material into germline cells so that the inserted material becomes part of the host organism’s genome and can be passed to progeny. Wild populations can be modified if enough modified individuals are released and if the modification enhances the organism’s reproductive fitness. The American chestnut restoration project uses conventional gene editing to create a blight-resistant American chestnut tree. A variation on this strategy involves the use of “dominant lethal” genes, also known as “self-limiting” genes, which cause premature death in host organisms. If large numbers of insects with dominant lethal genes are released into the wild to mate with wild-type insects, then the offspring will inherit the dominant lethal gene and die as larvae. Successive releases over time will reduce the local population of that species. Slightly different versions of this insect control strategy—known as the release of insects with dominant lethal, or RIDL—have been tested in different insects in different contexts. The biotech company Oxitec, Ltd., has created an *Aedes aegypti* mosquito, diamondback moth, pink bollworm, Mediterranean fruit fly, Mexican fruit fly, and olive fly with dominant lethal genes. It has tested its mosquito at several sites, including the Cayman Islands, Panama, Malaysia, and Brazil,⁴ and achieved an 80 to 95 percent decline in *Aedes aegypti* populations in some trials.⁵ A field trial of

the modified *Aedes aegypti* was proposed in the Florida Keys in 2011 but temporarily abandoned in 2016 after a voter referendum showed overwhelming community opposition to the trial.⁶ After developing a “second generation” genetically modified male *Aedes aegypti* mosquito (OX5034), Oxitec applied to the U.S. Environmental Protection Agency (EPA) for an experimental use permit to conduct field trials in Monroe County, Florida, and Harris County, Texas. The company received permission from the EPA and local authorities in Florida to conduct field trials, which are expected to be held in the spring of 2021. Local authorities in Texas have indicated that the decision about whether to approve field trials in the House area is on hold.⁷ Oxitec’s diamondback moth was tested in field trials in October 2017 in upstate New York.⁸ This trial, too, had faced opposition, in this case from organic farmers.

Another variation on genetic strategies for modifying populations makes use of gene drives, which are processes that increase the likelihood that a gene and the trait it confers will be passed to offspring. If the transmission rate is high enough, the trait may “drive” throughout a reproductively connected population. Gene drives occur naturally³ and can also be created by researchers, and the discovery in 2012 of CRISPR-based gene editing techniques has led to rapid advancements in gene drive science.⁹ In principle, gene drives could be used to modify an entire species; for example, disease-resistance might be imparted to *Anopheles* mosquitoes to eliminate malaria.¹⁰ Gene drives might also aim to suppress or even eliminate a population, perhaps by biasing the population’s sex ratio.³

The Call for Public Engagement

Proposals for genetically modifying wild-type organisms hold the possibility of very significant, maybe transformative benefit. They could also pose very significant risks and are

often surrounded by a very high level of uncertainty. They also raise questions about the attitudes people have to risk and uncertainty,¹¹ the values people attach to the natural world and the human relationship to it,^{12,13} how such values should be weighed alongside tangible benefits to human health and welfare, and how—and perhaps whether—they ought to influence government policy about biotechnological research and management of the shared environment.¹³

Given these technical and moral complexities, many science and technology advisory bodies, scientists, research funders, and others have called for public engagement in the science, ethics, and governance of various biotechnologies, including gene editing research in nonhuman organisms.^{14,15,16,17,18,19} These commentators have offered several justifications for engagement, including that it can increase the public's understanding of science, allow scientists and policy-makers to learn from the public about the goals of research and the context in which the research would be done, enhance the legitimacy of the policy-making process, and produce more just outcomes. As one of the leading proponents of public engagement in environmental policy-making put it, "the case for participation should begin with a normative argument—that a purely technocratic orientation is incompatible with democratic ideals."²⁰ The National Research Council echoed this view in 2008: "public participation is intrinsic to democratic governance."²¹

Public engagement can take many forms: town hall meetings, public hearings, citizens' panels, citizens' juries, consensus conferences, focus groups, opinion polls, surveys, negotiated rule-making, and referenda.²² Some forms of public engagement—such as citizens' juries and assemblies, deliberative polls, and World Wide Views—are designed to be *deliberative* rather than merely to provide information.²³ Deliberative engagement begins "with the recognition of the underlying values inherent to public problems, and focuses on developing mutual

understanding and genuine interaction across perspectives, which then provides a base to support the constant adjustment, negotiation, and creativity required to tackle wicked problems.”²⁴

Public deliberation is typically considered useful and appropriate for addressing policy problems that involve high levels of value conflict and for which technical expertise is insufficient or where the institutions charged with making decisions are not trusted.²⁵ Proposals to genetically modify wild populations of organisms might therefore be well suited to public deliberation, and indeed, some of the most prominent commentary on genetic technologies that might be used to alter the shared environment calls expressly for deliberative forms of public engagement. The Presidential Commission for the Study of Bioethical Issues identified “democratic deliberation” as one of five principles for the governance of synthetic biology and other emerging technologies (2010), and the 2016 National Academies of Sciences, Engineering, and Medicine report on research into and use of gene drives describes public engagement as providing opportunities for “mutual learning” and notes that “research on deliberation suggests that engagement can foster ‘reflexivity’ among participants, in the sense of creating opportunities for reflexive thinking to clarify one’s beliefs and understandings, reflect upon and revise one’s opinions, and gain insight into how different interests and values are situated in conversations about how to proceed.”¹²

We argue that there are three reasons to think that gene editing in the wild warrants broad public deliberation. First, this is an issue with high moral stakes that is compounded by low salience for much of the public. Gene editing in the wild has potential tangible consequences and conceptual implications of altering the shared environment by modifying species, as well as the overall political economy of genetic science. The potential tangible consequences—that is, the possible effects on human health and well-being as well as non-human and ecosystemic well-

being—are easy to indicate, even though understanding them and estimating them is difficult. The morally significant aspects of gene editing in the wild go well beyond its tangible consequences, however. In fact, what may be most significant about the moral stakes surrounding gene editing in the wild are its potential conceptual implications—its affront to some ideas about nature and the human relationship to nature. For example, many Indigenous peoples have deep and varied moral traditions about the human relationship to nature. Some members of Indigenous cultures see genetic alteration as a violation of nature, while others offer support for at least some instances of genetic alteration.^{26,27} For many people, especially those with the deepest, longest-lasting relationships to the land, nature is more than a resource; it is a source of meaning and intrinsic value.²⁸ For others who may be uncomfortable with gene editing, the technology represents a threat to religious practices and worldviews.

Currently, the public conversation about gene editing is dominated by those interested in its public health or conservation applications. These include private organizations such as Target Malaria, Island Conservation, and the American Chestnut Foundation, as well as government agencies such as the U.S. Defense Department’s Defense Advanced Research Projects Agency. The aims of the research these organizations are funding are noble: to reduce morbidity and mortality related to infectious disease and protect endangered species. But there is a danger that the noble aims of the current dominant leaders in this space will foreclose critical discussion of other values and competing interests. These high stakes are not likely to be appropriately addressed through existing democratic governance mechanisms, like federal agency rulemaking or local government decision-making, as those mechanisms currently operate.

The high moral stakes are easily underappreciated amidst the low salience of gene editing wild organisms to the average person. Proposals to release genetically modified organisms are

unlikely to receive sustained political attention because they will be eclipsed by other issues that affect voters more viscerally and immediately and that are more familiar to them.²⁹ It is not unreasonable for people who are focused on meeting their families' immediate needs to ignore debates about gene editing. But this problem may exacerbate injustice in who gets heard in debates over the development and use of biotechnologies. Existing democratic governance mechanisms do not capture the views of people who do not have time or resources to form them; that does not justify ignoring them. Possibly, public deliberation can create room for historically unheard voices and improve the odds that policy-making bodies take their views seriously.³⁰

A second reason for public deliberation about wild release of genetically modified organisms is the multiple and manifest forms of uncertainty that surround the prospect. Outcomes of many proposals for gene editing wild organisms are surrounded by a high degree of uncertainty. Aversion to uncertainty may fuel strong opposition to such proposals, even if the status quo presents significant risks. Polling and governance processes that do not account for this tendency may therefore also not address risk and uncertainty appropriately. Possibly, however, under conditions in which the public deliberations acknowledge and accommodate uncertainty, the deliberants' views would themselves accommodate uncertainty and evolve.

A related issue is sometimes referred to as value uncertainty³¹ or ambiguity.³² A key source of ambiguity has to do with the valuation of nature—which as noted is hard to express and articulate, can take many forms, and is not universally shared.^{33,34} In part, the ambiguity about gene editing in the wild is due to the complexities of some of the proposed releases of genetically modified organisms. The prospect of using gene editing technologies to protect species involves a tension between altering and preserving, and its very coherence is sometimes challenged not only by critics of conservationism but also by some advocates. Resolving the

tension requires thinking about what nature means and what is important to nature. Is nature, understood as a contrast to “artificial” or “humanized,” consistent with human efforts to protect or “restore” nature—or do those efforts destroy the idea of nature?

A final reason to support public deliberation about policy concerning the release of genetically modified organisms into the environment is the possibility that the policy debate suffers from significant distortion.³⁵ Distortion might result in part from the very difficulty of some of the moral concepts, especially those having to do with ambiguity and with the human relationship to nature. A go-slow approach to research and development might be treated in such a way as to amount to a full halt.³⁶ On the other hand, the political economy of science generates its own distortions: reliance on technological solutions can lead to a lock-in phenomenon in which technological solutions appear to be the only possible solutions to a problem. Similarly, in a kind of distortion of scope, issues around intellectual property, control of seed, and the power of agribusiness are often reduced from concerns about the structure of the political economy into more limited concerns about “safety” because of the remit of regulatory systems. Distortion may also be actively produced by the proponents and opponents of genetically modified organisms.³⁷ Public deliberation may clarify the terms of debate and allow for less distortion of the facts.

The Challenge: Broad Public Deliberation

There is good reason to create opportunities for deliberation in the context of decision-making about genetic technologies for modifying populations of wild organisms. For example, when members of the public chant “hell no, GMO” in response to proposals to introduce genetically modified organisms into the environment, their reaction may reflect uninformed fear of this technology, or it may reflect a preference for preserving natural phenomena, or a special

disvalue attached to risk and uncertainty.¹¹ Public deliberation both offers the public an opportunity to set uninformed fear aside and encourages policy-makers to consider public values that may be deeply held even if they are hard to express and discuss. Such values frequently are poorly incorporated into formal policy analysis mechanisms such as cost-benefit analysis and risk assessment, which can generate public distrust in policy-making and lead to calls for stringent constraints on science and technology.³⁸ Appropriately structured deliberations may guide decisions in ways that are more consistent with deeply held public values and preferences. But those who have called for broad public deliberation in this context have not offered much guidance on these problems. The PCSBI called for “a broader, ongoing national conversation about science, technology, society, and values,”³⁹ but it offered few suggestions about how it should be done. The PCSBI presented its own work as an example of democratic deliberation, although its process arguably did not sample the public’s views sufficiently to be “democratic.” The National Academies report on gene drives offered a number of recommendations to bear in mind while framing a public engagement effort, but its discussion was concerned chiefly with community engagement specific to an application, and it expressly concluded that there could be no “standard approach” to public engagement to be used across all gene drive applications. While it recognized the potential need for deliberation among broader “publics”—groups that would have to be constructed, by those carrying out deliberation, out of the overall public, it did not attempt to identify the criteria for those publics, nor did it describe how such deliberation should occur. In this special issue, we identify the design issues that must be addressed to successfully implement these calls.

Key Issues in Designing Broad Public Deliberation

Experimental and observational studies provide some evidence of the benefits of deliberation.^{40,41,42,43} Important questions arise, however, about how to carry out public deliberation for proposals to modify populations of wild organisms. How should public deliberation be conducted—who should it include, for example, when should it occur, how should the deliberations be moderated, and how should the results of these deliberations be used to shape collective decisions?

[EDITORIAL NOTE: The next paragraphs discuss the specific essays in the special report. An author of this introduction redacted authors' names, replacing them with dashes. For the peer review process, I have inserted the titles instead; please pardon any clunkiness that has resulted! -Laura]

Framing the question and deciding when to hold broad public deliberation: As the essay “Deficits of Public Deliberation in U.S. Oversight for Gene-Edited Organisms” emphasizes in this special report, adequate assessment of gene drive proposals—particularly of the most novel, risky, uncertain, and controversial proposals—cannot be accomplished with public deliberation. This makes at least downstream and local deliberation essential. However, as discussed in “Does Gene Editing in the Wild Require Broad Public Deliberation?,” if public authorization is important for the very idea of gene editing in the wild, and if the relevant stakeholders in that idea include the broad public, then arguably the deliberative activities should occur very early in the technology’s development, perhaps before any particular proposals are launched. This also affects how the question to be deliberated should be framed. Although some kinds of gene editing in the wild do appear to be more novel, risky, uncertain, and controversial than others, all of them must, for now, remain on the table for consideration; deliberation about the idea of permitting gene editing in the wild requires that a maximally wide range of cases are put before the public. Further, if deliberation should occur early, then the topics under deliberation may have to be framed so as to address general categories of proposals rather than individual

proposals. It may not even be possible to take many specific proposals up to a broad level. However, framing the technology very generally may heighten the levels of uncertainty and abstraction in the topic. Deliberation tends to go better when the topic pertains to something that is reasonably well-understood and has clear personal or local import, as with biobanking policies or policing practices. “The Decision Phases Framework for Public Engagement: Engaging Stakeholders about Gene Editing in the Wild” argues for a *decision phases framework* for public deliberation that includes upstream engagement that precedes the development of technological solutions and downstream engagement that persists through the deployment and continued study of biotechnologies.⁴⁴

Choosing participants: There is a consensus that public deliberations should include participants beyond those immediately or directly affected by a specific proposal, bureaucrats, and those who have something at stake. This is what we mean by “broad” public deliberation. Furthermore, as explained in the essay “Narratives in Public Deliberation: Empowering Gene-Editing Debate with Storytelling,” deliberants should reflect “the diversity of perspectives in the population.”⁴⁵ Indeed, broad representation in deliberative forums can help to overcome the “democratic deficit” that the author of the “Deficits of Public Deliberation” essay observes in existing rulemaking mechanisms, which are often dominated by federal agency staff and product developers. This author calls for expanding opportunities for broad public deliberation because, currently, the need for it is great and the use made of it, to inform rulemaking and oversight activities, is inadequate.⁴⁶ Similarly, “Envisioning Deliberation with a Cultural Theory Lens” argues that if government agencies conduct public deliberations, it is important for them to capture a range of values and viewpoints,⁴⁷ and “Regulating Gene Editing in the Wild: Building

Regulatory Capacity to Incorporate Deliberative Democracy” calls for adequate funding of these efforts to integrate new deliberative activities into the rulemaking process.

Beyond the consensus that deliberative forums should be “broad,” however, there are strong disagreements about how to achieve this, and any effort to implement a broad public deliberation must consider whether its recruitment strategy matches the purpose of the exercise. If the purpose of broad public deliberation is to find out what the public would think “should be done if they could consider the issue under good conditions,” as the essay “Deliberative Public Consultation: Criteria and Methods” expresses, then it makes sense for the group that is brought together for the purpose of the deliberation to be a “representative microcosm of the public” and use random sampling to ensure inclusion.⁴⁸ If the purpose is either to overcome entrenched social inequalities that tend to prevent participation or to make sure that people who may be more directly affected by benefits or harms of the release of a genetically modified organism in the wild are heard, then it may be important to oversample these populations.⁴¹ Beyond this, “Giving Voice to the Voiceless in Environmental Gene Editing” invites us to consider novel ways to include the voiceless, including nature itself, including efforts to grant representation to people who may speak on its behalf.⁴⁹

Addressing power: The literature on deliberation suggests broad criteria for conducting successful and legitimate deliberation.^{50,51,52} For example: All participants should have an equal opportunity to voice their concerns. Power differences within the group must be redressed. All people who may be affected by the decision ought to be represented in the discussion, and in some cases, groups that are not immediately affected but have historically been excluded from collective decisions should be represented as well. But representation, alone, may not be enough. “Empowering Indigenous Knowledge in Deliberations on Gene Editing in the Wild” argues that

“direct confrontation of the historic and ongoing power imbalances that are relevant to gene-editing, and how those may be reified in deliberative spaces,” are necessary at every stage in the deliberative process.²⁸

Accounting for and capturing perspectives that are hard to express: Although value conflict is posited as a reason for conducting public deliberation, these cases involve values that are difficult to address in public policy and perhaps even to express and discuss in intimate settings. For many of these technologies, it is difficult to understand, much less quantify, costs and benefits to guide decisions. At stake here, for example, are questions about the ideal human relationship to nature—about whether to treat wild species as economic resources or as intrinsically valuable entities worth protecting and preserving and about how that value should be weighed against public health or economic benefit. Big moral questions loom about individual liberty to do as one wishes on one’s own land, scientific freedom to follow one’s nose, and the limits of those freedoms for the sake of collective flourishing. Social and political context shapes our values; social and political inequities and procedural injustice—not including people in decisions that affect them, as a result of discrimination, systematic disenfranchisement, or simply ignorance—cannot be dismissed. These conditions influence our values and our ability to talk about them.

One of the key issues in running broad public deliberation about gene editing in the wild is to ensure that these background conditions and perspectives can be accommodated. The essays here explore several routes for doing so. As “Narratives in Public Deliberation: Empowering Gene-Editing Debate with Storytelling” reminds us, capturing narratives can be used to help the participants in broad public deliberations introduce new ways of understanding and overcome the bias in favor of arguments that reflect dominant academic and political economic perspectives.⁴¹

In the context of doing so, it is crucial for trained facilitators in deliberative forums, and those who are responsible for interpreting and reporting the results of these conversations, to separate legitimate values from unhelpful emotional responses, and to eliminate manipulative and overbearing communications.³³

Conclusion

Good use of technologies to genetically modify populations of wild organisms depends on mechanisms for incorporating society's values about what may and should be done to the shared environment. Use and even ongoing research into these technologies may depend on politically legitimate and trustworthy decision-making processes. The essays in this report make progress toward meeting these requirements. In addition to advancing the scholarly understanding of public deliberation, the report offers recommendations to guide those in science and policy-making concerned about public deliberation, and it can foster more responsible claims about when public deliberation is necessary and what it can accomplish. It is not a handbook for people who want to design deliberative forums, but it is meant to show the trade-offs in some key elements of design that people planning broad public deliberations have to make.

Notes

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