



Survey
Genome Editing Technologies
in Conservation
September 2020

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INTRODUCTION

Recent proposals by groups like the International Union for Conservation of Nature (IUCN) as well as research scientists and institutions and some rewilding proponents, suggest that a suite of genetic engineering (now called genome editing) technologies may support and even advance multiple goals in conservation.

The suggestion has been met with a wide spectrum of responses, both for and against. But absent from much of this discourse have been the voices of conservation groups themselves. It is extremely rare for civil society groups working in conservation to publish work on this topic or to have clear published policies stating where they stand on the use of genome editing and its regulation. This is in spite of the fact that work in this area is advancing rapidly and that genetically engineered organisms released into the wider environment may interact with and have impacts on the natural world, on activities that take place within the wider environment such as agriculture and ultimately on human beings.

We therefore contacted major conservation groups, encompassing all specialities, to better understand where their thinking and their work is in terms opinions, policies and priorities.

METHODOLOGY

The survey was sent to 83 major UK and European-based conservation organisations – we believe the first time UK conservation groups have been surveyed about this issue - between May and July 2020. This included relevant UK members of IUCN.¹ The survey was also sent to a handful of specialist journalists and conservation ‘personalities’ as well as UK government backed agencies and commissions concerned with conservation. The total number of groups and individuals who were sent the survey was 102.

Respondents represented a broad range of both general and specialist conservation areas, including mammals, insects, plants, birds, land use, marine environment, parks and protected areas, zoos, environmental education and aspects of biological and conservation science (Q6). That said, none of those who responded to the survey focused specifically on amphibians, inland waterways, rewilding, conservation law or eco-certification.

In total there were 25 responses, with 13 responding on behalf of their organisation and 12 responding as individuals (Q1). To ensure that respondents felt confident to answer fully we agreed to preserve the anonymity of all those who took part in our reporting.

A further note on the response rate and additional input

In the first half of 2020, during the period of global lock-down due to COVID-19, A Bigger Conversation undertook a series of surveys of citizens and other civil society groups as well as interviews in order to continue its work.

Moving online, which many civil society groups did, made sense in theory. In practice many organisations had members of staff were furloughed (and therefore not able to work for their

¹ <https://www.iucn.org/about/members/iucn-members>

organisations at all) or on limited hours during this time due to the pandemic. Some organisations were sent three or more reminder emails before responding.

In spite of repeated follow-ups many who were sent the survey did not respond. Some respondents emailed to say that although the organisation did not have an official policy, the topic was of interest to them and they were happy to respond in a personal capacity.

For this particular survey there were also, initially, some difficulties with survey recruitment. It was not straightforward to identify the correct member of staff to contact in the largest conservation organisations. The survey recruiting email was initially sent to the chief executive and science and policy directors. In many cases, however, the eventual respondent was not the person initially contacted.

Amongst the individual responses were people working at large organisations, specialist charities and zoos and in academia as well as freelance consultants.

Even with repeated requests we received no response from several major UK conservation organisations which we would have expected to be engaged with this issue and to have policies in place.

Four organisations declined to fill in the survey and provided reasons for this:

“We don’t have much to add to this conversation...rewilding usually only involves the reintroduction of species that were already present in the environment and we’re not sure how much impact gene-editing would have specific [sic] in our brand of conservation”

“We discussed your inquiry internally and decided we are not in a position to fill out the survey. ASC is a certification scheme for aquaculture rather than a conservation group, therefore your survey isn’t really applicable to us and we don’t have positions or policy on the issues you’re researching”

“We discussed this at our Research Committee meeting and decided that it wasn’t a priority for us, [and] felt it was not a strong match with our research expertise”

Another felt it could not complete the survey since Question 4 did not include a choice that would accurately reflect the fact that they had “No position currently” and would, they felt, have forced them to answer inaccurately.

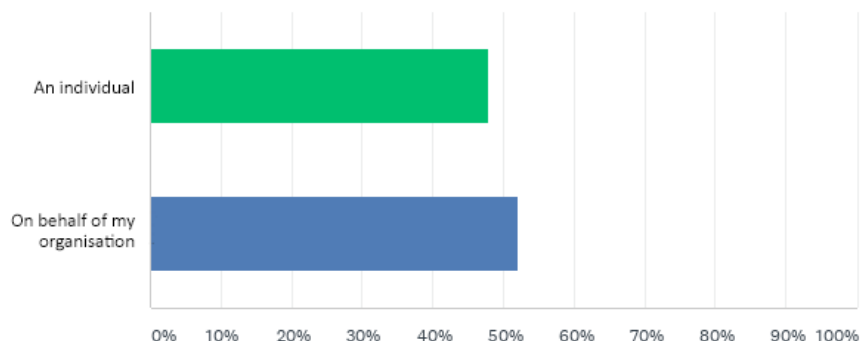
We viewed these refusals as important additional input.

Three organisations to which we sent this survey, whose work encompasses both conservation and agriculture in relation to animals, land and landscape, had already responded fully to another of our surveys on genome editing which we were conducting at the same time. Although aimed at different focus areas this suite of surveys included several of the same key questions around regulation. We note their responses amongst the comments in this report where relevant.

Taken together, those who responded to the survey or provided reasons for not responding, meant we collected relevant data from 32 organisations.

RESULTS

Q1 I am responding as...

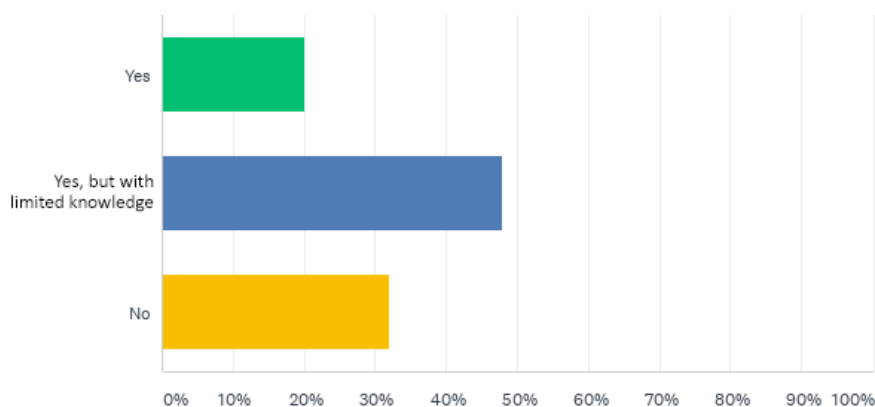


Participants were asked to indicate whether they were responding on behalf of their organisation or as an individual.

Our initial enquiries suggested that many of the UK's conservation organisations were unlikely to have any policy at all on genome editing and might decline to answer because of this. We therefore provided an option for participants within the organisation to respond as individuals with expert knowledge in their field. This option also allowed individual researchers or consultants in the field to contribute.

Whether responding on behalf of an organisation or as an individual all respondents held senior positions. In all 52% of responses were on behalf of organisations and 48% were from individuals.

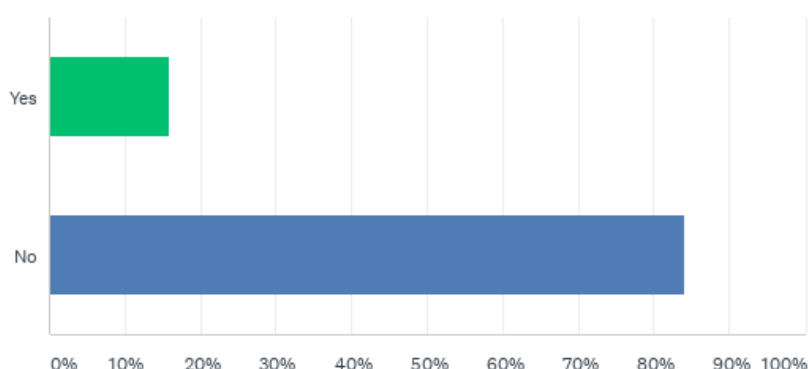
Q2 Are you/your organisation aware of proposals, by e.g. IUCN and research institutions, to consider using genome editing technologies (gene editing, synthetic biology and gene drives) to make progress towards conservation goals?



Seventeen respondents stated that they were aware, although a majority of these (12) stated that they had only limited knowledge. Eight, mostly from smaller specialist organisations, stated that they were not aware

One respondent from a conservation organisation with international outreach that chose not to fill in the survey stated that he is *“on the IUCN Synthetic Biology Task Force and has been involved in developing the draft IUCN policy”*.

Q3 Do you/your organisation have an official position on genome editing in conservation? If so, what is it?



Just four respondents stated that they had an official position on genome editing. This included two UK-based and two EU-based organisations. One large UK NGO noted:

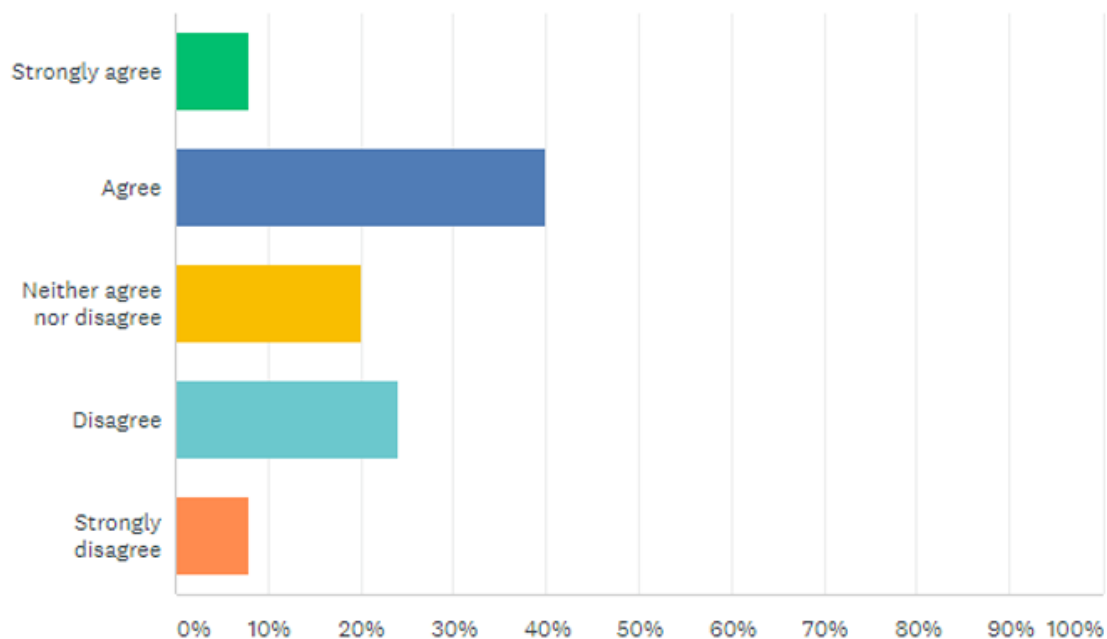
“Genome editing is a very new technique that hasn't been assessed at all in regards to its environmental impacts. So far, the communication around gene editing is more a promise on potential benefits that are not based on any evidence. Various of these promises are very similar than the first generation of GMO were developed in the 1990ies and never delivered any of them”

The other highlighted the necessity of demonstrating the ‘benefits to society’, concern about damage caused by insecticidal GM crops and glyphosate use, as well as gene transfer and the importance of the Precautionary Principle. It said:

“While the principle is often invoked as the enemy of science and innovation, it is nothing of the sort; it is simply a sensible approach to avoiding harm occurring while regulators dither, or hide behind uncertainty, to avoid taking difficult political or economic decisions”

Two individuals also had clear positions one stating that *“National authorities should decide on their regulation, based on existing international guidelines i.e. Cartagena Protocol.”* Another said genome editing should only be considered *“at the point of an imminent extinction when all other possible methods have been tried and failed”*.

Q4 How would you/your organisation respond to the statement: "Genome editing may have benefits for conservation"?



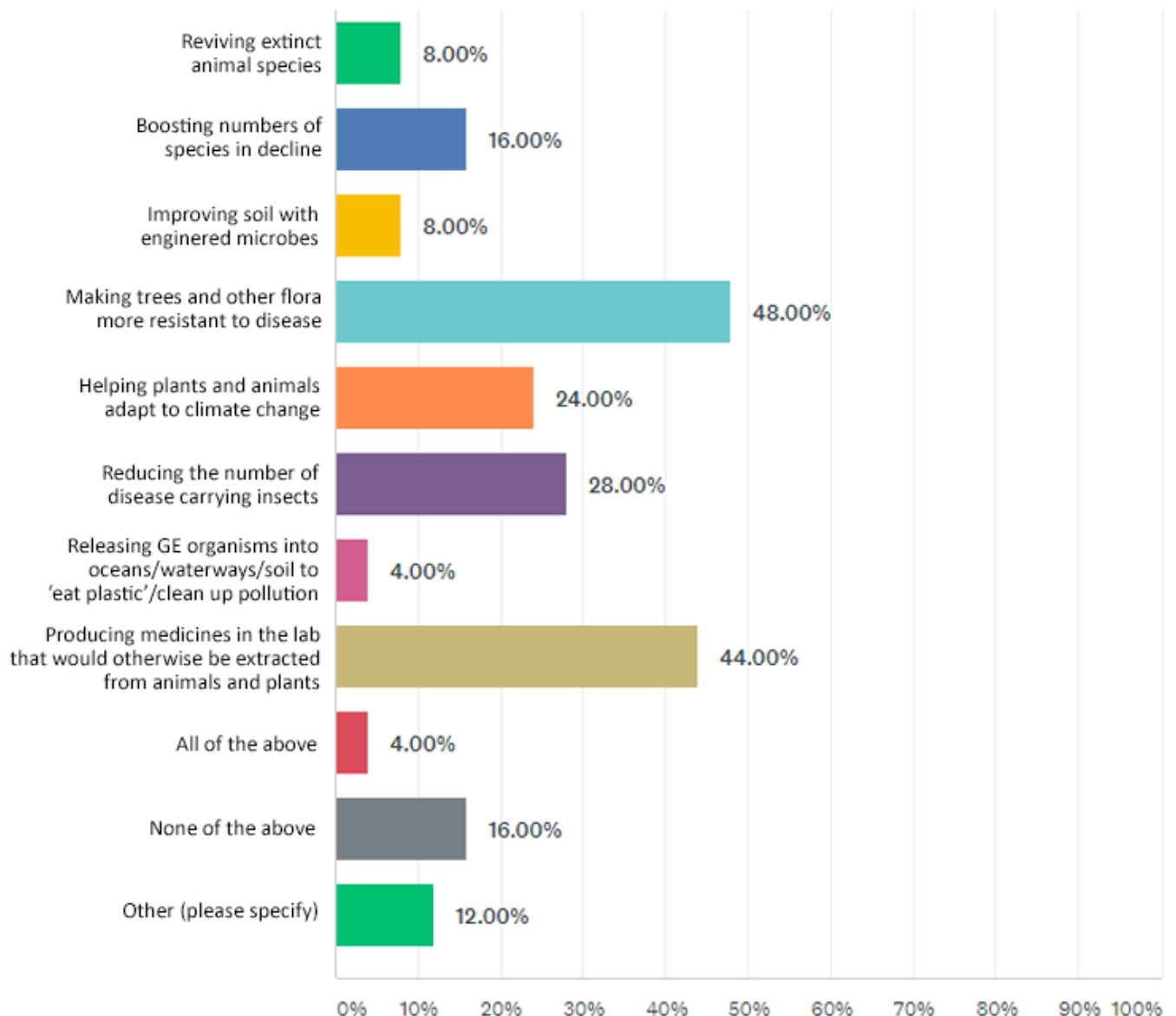
Eleven respondents agreed that genome editing may have benefits for conservation, with one strongly agreeing. Eight disagreed, with two strongly disagreeing.

There was no discernible pattern or common thread (e.g. size of organisation or speciality) amongst those who agreed or disagreed with, or were neutral about the statement.

There was no space for additional comments on this question however one specialist organisation provided a separate comment querying the question itself.

"Q4 was tricky - virtually any action, even severely negative ones, "may have" benefits (intended or unintended, and however small), so strictly one should answer agree, I guess what is important is the relative size of those benefits"

Q5 Which uses for genome editing do you/your organisation feel hold the most promise (you may tick more than one):



Most respondents chose at least one of these uses. Only one, a specialist in ornithology, chose “all of the above”. Four respondents, a mixture of small and large NGOs and an individual, chose “none of the above”

The most popular response was “*Making trees and other flora more resistant to disease*” followed by “*Producing medicines in the lab that would otherwise be extracted from animals and plants*”. The least popular response was “*Releasing genetically engineered organisms into the oceans/waterways/soil to ‘eat’ plastic/clean up pollution.*”

Around a third of respondents provided extra comments.

One, a specialist in wildlife epidemiology, added an additional choice:

“Modification of virulent wildlife pathogens that are causing biodiversity loss having been moved outside of their natural range by human activities”

Another added another that while the possibility of using gene drives to eradicate invasive species “with usual precautionary risk assessment requirements” was attractive, there was a need to address the root causes of these problems and proposed the need for systemic change:

“A number of these issues - extinction, climate change, eating plastic and destroying vectors feel like sticking plasters that could be used to avoid taking action that would address those issues at root or restore the landscapes and habitats that could be more robust to those issues”

One organisation that felt unable to choose any of the options and therefore just ticked ‘other’ noted: *“We don’t have a view to be able to comment.”*

Interestingly, several respondents who disagreed with the statement in Q4 nevertheless ticked one or more of these choices when specified.

One, for example, chose *“producing medicines in the lab that would otherwise be extracted from animals and plants”* but added that because of concerns about genome edited plants cross-breeding with wild and conventional plants in the natural environment,

“GE must be limited to a laboratory setting where the risk of escape and contamination can be controlled”

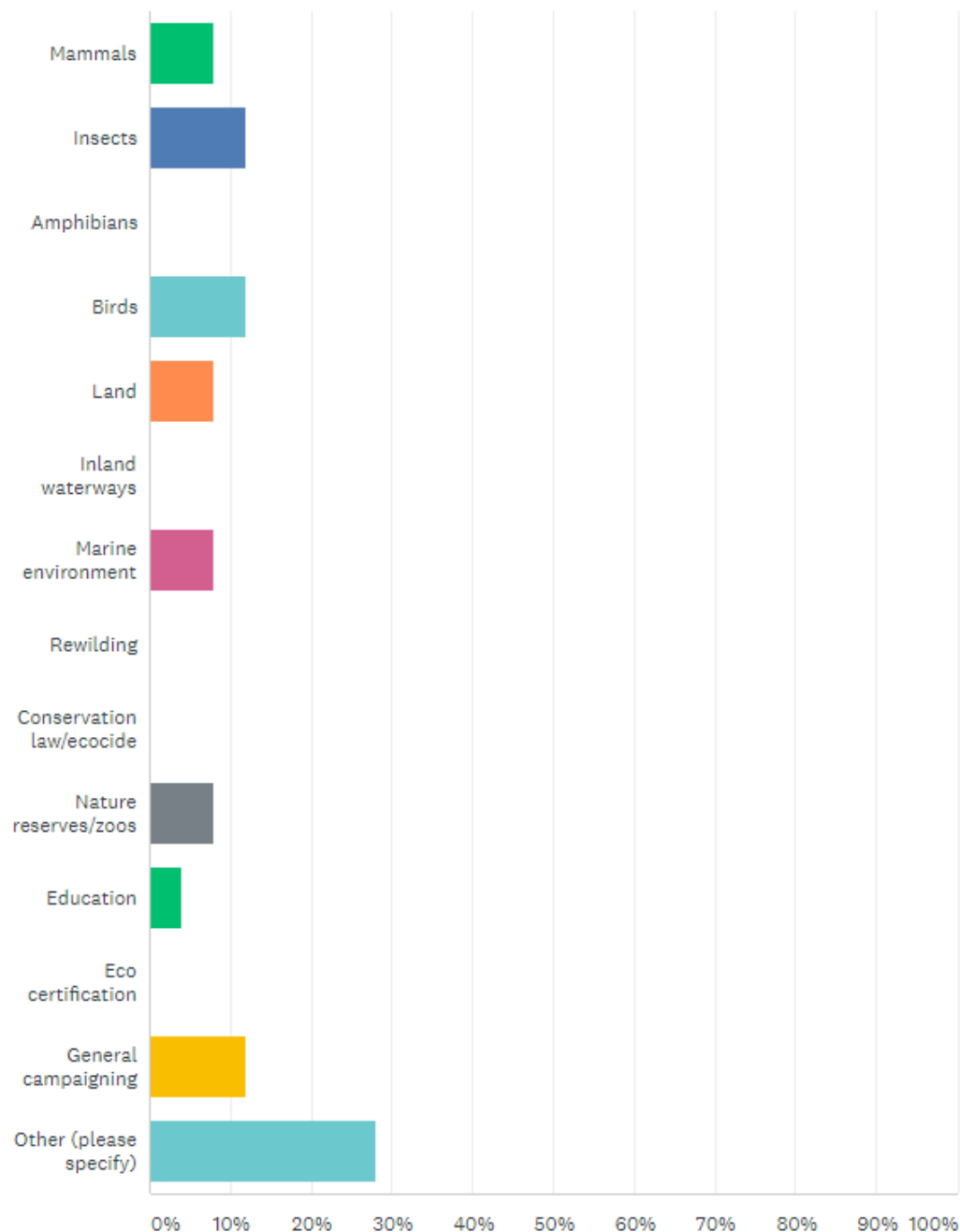
Another stated:

“This one was also difficult without background information, some are obviously better developed (and more widely known) than others - the benefits tend to be well promoted, but are the “costs” equally well considered (given that many of them may be unintended)?”

This was echoed by individual respondent, a specialist in ornithology who added:

“Some of these sound great - but they don't come risk-free and I don't understand the risks (nor, actually, the chances of success)”

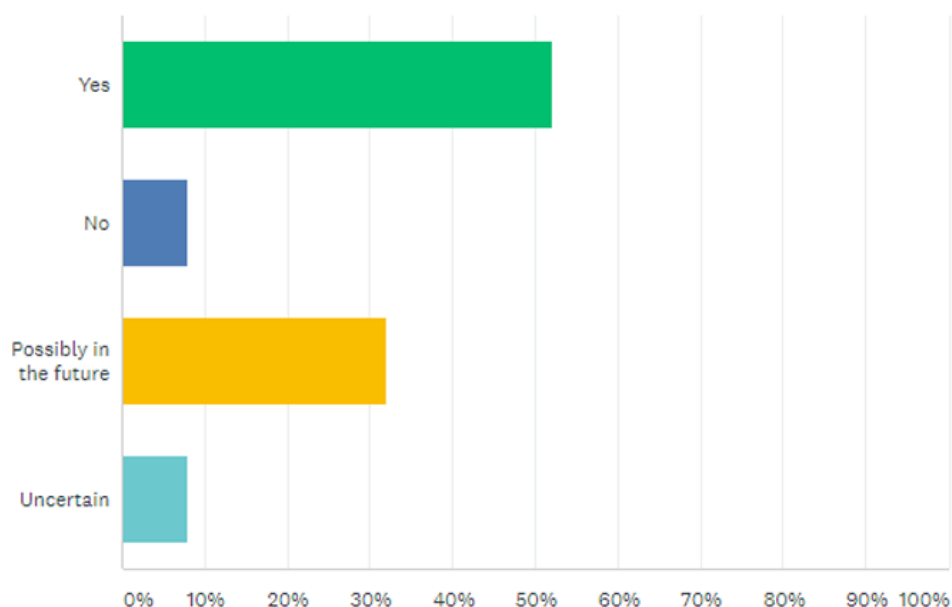
Q6 Which option most closely describes the focus area of your/your organisation's work?



Twenty-eight percent of respondents added additional clarifications about their work which indicated that it involved a mixture of the indicated fields, or that they worked specifically in “Plant research into genomic dynamics and its evolutionary and ecological impact,” or “invertebrates, nature conservation and agriculture” or had a “broader remit in in terms of evidencing the impact of land use on biodiversity more generally, and leaders in the field in terms of citizen science/ engagement.” One individual, who worked in an organisation representing parks and protected areas, challenged the relationship, implied in the question, between nature reserves and zoos.

See Methodology and Conclusion sections for more details and analysis.

Q7 Do you/your organisation see the issue of genome editing in food and farming as relevant to its area of work?



The majority of conservation organisations and individuals responding stated that genome editing in food and farming is relevant to their work now (52%) or possibly in the future (32%). Two respondents stated no and two were uncertain. No reasons are given.

Note that some organisations that chose not to respond to the survey did so because they did not feel that the issue was relevant to their work (see Methodology section). The organisations that did respond are, therefore to some extent a self-selecting group of those that feel it is relevant to them.

Q8 Do you/your organisation believe that genome editing in conservation should be banned, allowed or subject to a moratorium pending further consideration?

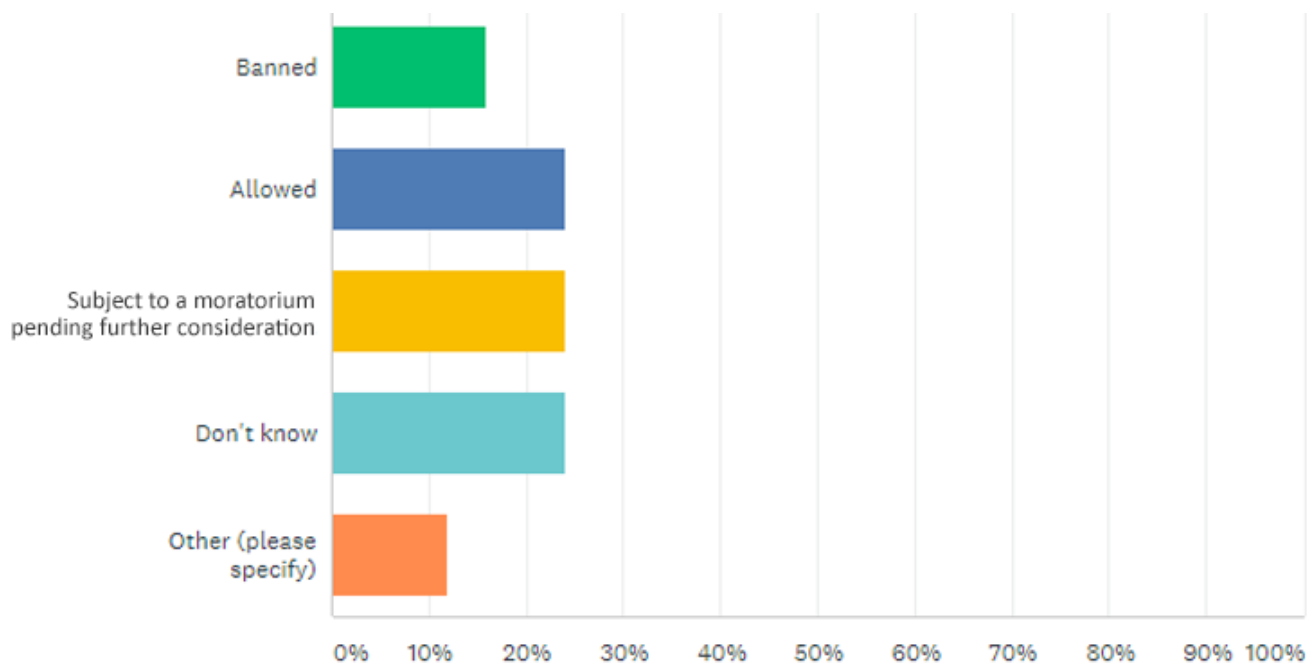
Opinions were fairly evenly spread: six respondents agreed that genome editing should be allowed, six agreed that it should be subject to a moratorium, and four felt that it should be banned. Six stated 'Don't know' and three stated 'other'. In the UK at least, this is a fairly common split, which has not changed much with the introduction of new genetic engineering techniques.

Two organisations involved in land management which responded to another survey in this body of work (see note under Methodology) said that genome editing should be allowed.

Once again there was no obvious linking factor between those who felt the technology should be banned or allowed or those who suggested a moratorium was more appropriate.

Among those who felt there was a role of genome editing, one respondent qualified his comments with:

"I'd love to be able to say that we never need to consider using these techniques, but the truth is that many species are facing extinction for which traditional conservation approaches are not working or cannot work"



Among those who felt it should be banned one noted:

"We remain of the opinion that protected and setting aside habitats is the best way forward for the conservation of species. Not genome management."

Among those for a moratorium one organisation (that was among those who in an earlier question said it had no policy on genome editing) chose this section to explain its position on new plant breeding techniques (NPBTs):

"It is our position that any decision to approve new plant breeding technologies must be taken on the basis of thorough peer-reviewed and transparent science with long-term studies into the wider environmental and public health impacts. This review process needs to be conducted on each proposed new variety that utilises NPBTs since each new variety will have a different impact and different associated risks. Until this level of scrutiny is undertaken, there cannot be approval for use. Once a GE variety is released, it is impossible to control its spread due to the inevitability of cross-contamination, and consequently it cannot be approved without thorough investigation on its potential impacts"

The two organisations and one individual that chose 'other' made the following comments:

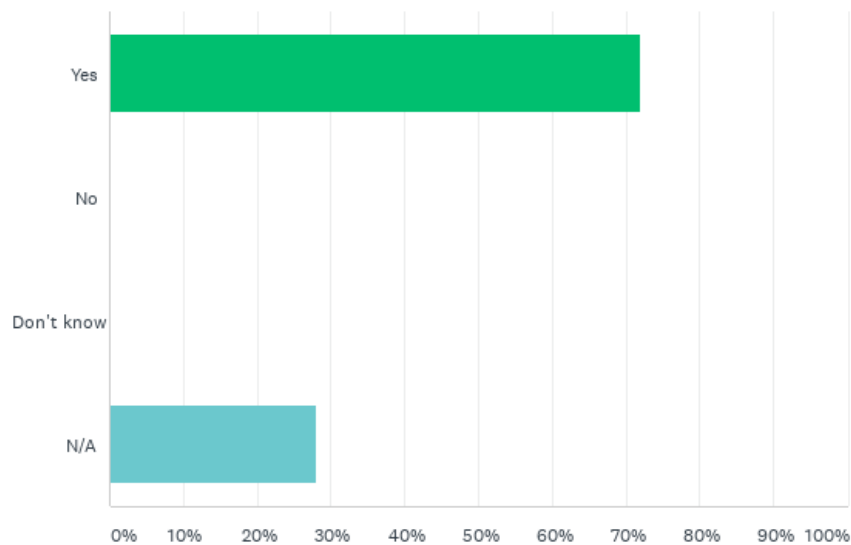
"We support the proposal in the motion on synthetic biology² under discussion for the IUCN World Conservation Congress, which is more nuanced than any of the options above"

"Carefully regulated, with proper risk assessment and approval process in place before it is allowed"

"Embarked upon very cautiously, with much greater public involvement and on a case by case basis"

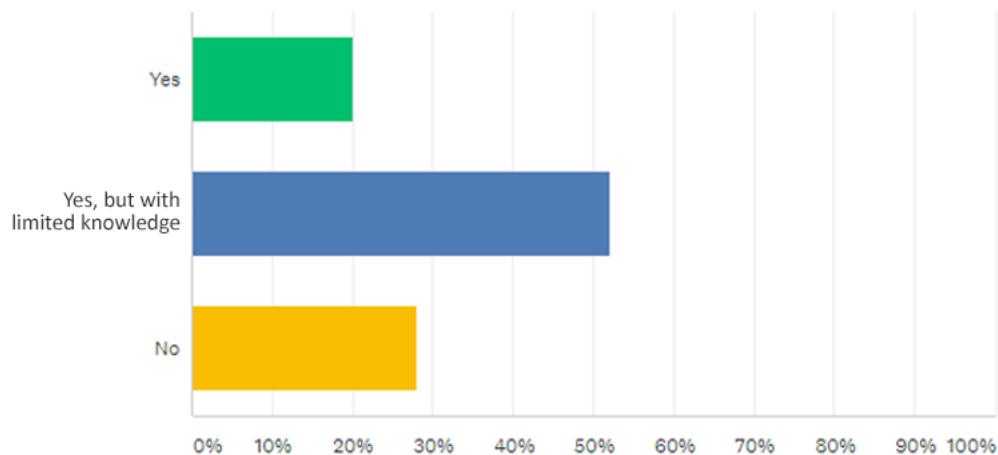
² <https://www.iucncongress2020.org/motion/075>

Q9 If you/your organisation believe genome editing should be allowed, do you believe it should be regulated?



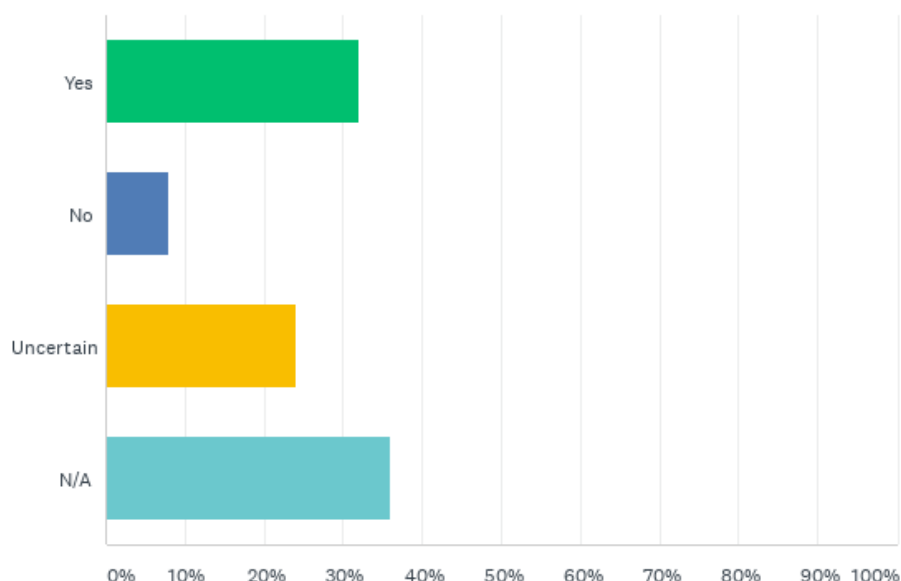
All the respondents that believed genome editing should be allowed (Q8), also agreed that it should be regulated.

Q10 Are you/your organisation aware that there are different methods of genome editing that claim different characteristics and different levels of benefit and risk?



A majority of the respondents were aware that there are different methods of genome editing (72%) although over half of these stated “yes, but with limited knowledge”. Just over a quarter (28%) stated no.

Q11 If you answered yes to Q10, would you/your organisation support different types of regulation for different methods of genome editing, e.g. some banned and some allowed?



For those aware of different methods of genome editing, a third (eight respondents) agreed that there should be different types of regulation for different methods. Two disagreed and six were uncertain.

Regulation should be appropriate to the risk and method. There may not be one rule that addresses all contexts.

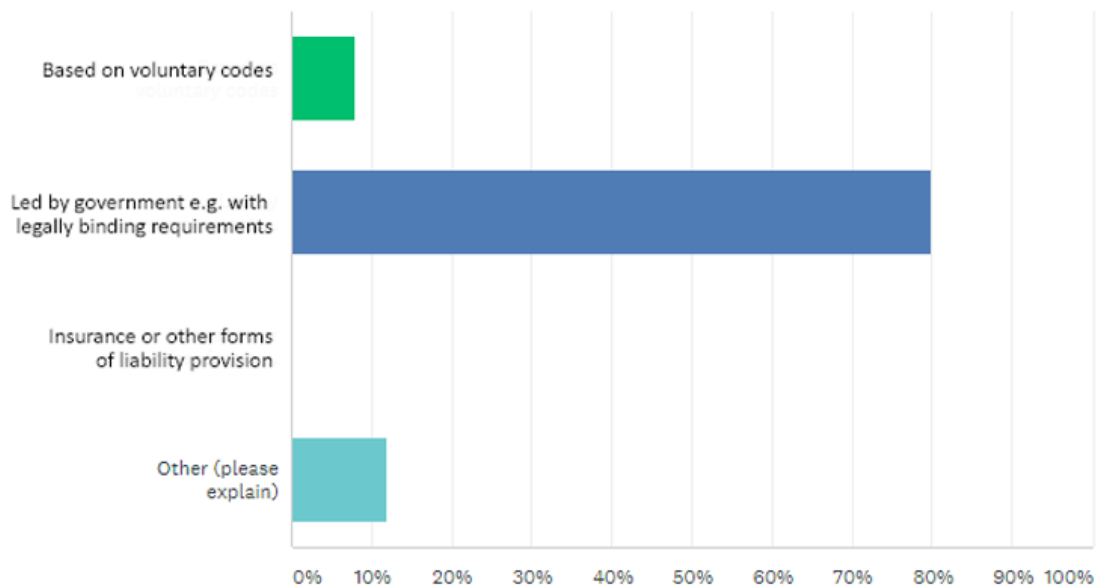
Q12 If genome editing for conservation purposes is to be regulated, would you/your organisation prefer it to be:

The majority of organisations (20 or 80%) agreed that regulation of genome editing should be led by government. Two felt that it should be based on voluntary codes. These respondents made no additional comments.

Those stating 'Other' included those who felt genome editing should be banned as well as one organisation that felt that regulation *"will require well-informed policymakers"*.

The comments also revealed some distrust in industry ability to self-regulate.

"Our experience unfortunately is that the industry seems to be continually trying to avoid appropriate pre-release risk assessment by trying to create loopholes in the legislation. This does not inspire confidence. In addition, when we have engaged with researchers developing GMOs that are likely to have profound ecological impacts on the environment, they have been dismissive of those concerns. In some cases, the risks are so big and obvious that assessing them should be part of the project from the start"



However, there still appears to be trust in government to set and enforce regulation. For example:

“It is essential that the regulation sits with Government to ensure that it is publicly accountable and have a strong and resilient enforcement mechanism to ensure compliance”

“To be effective, there need to be legal-enforceable sanctions if people break the rules”

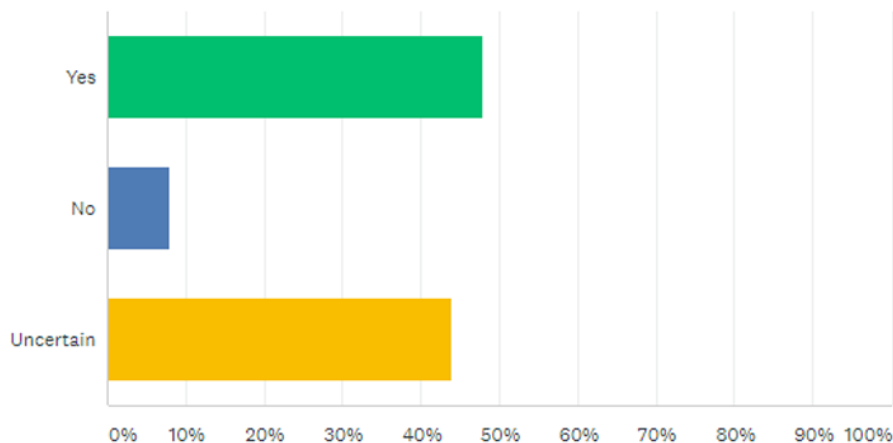
Although no one chose insurance as a specific option, one comment suggested that the combination of “regulation plus liability for negligence and insurance to compensate” those who might be adversely affected might be an effective belt and braces approach.

Q13 Do you/your organisation believe there are potentially harmful interactions between species that have been genome edited for conservation purposes and other living systems (e.g. farming)? Please explain.

A majority of respondents (48%) agreed that there are potentially harmful interactions between species that have been genome-edited and released into natural environments (e.g. for conservation purposes) with other living systems. Indeed, evidence of such interactions are well researched and widely understood.

It is, therefore, interesting (and for those who have concerns about the use of this technology, worrying) that many respondents (52% in total) replied “uncertain” or no to this question.

Once again there seemed no obvious link between those in this group, though it was more common for organisations/ individuals who felt that the technology was potentially harmful to support a moratorium



Additional comments reflected a range of views. One group that replied ‘uncertain’ qualified that view by saying this is why we need to apply the Precautionary Principle. Another acknowledged: *“There have been problems with GM crops.”*

Another added:

“It’s hard to imagine how there won’t be negative consequences, even if (or especially because) these are unintended”

However, a group working primarily with animals that stated it was uncertain ‘uncertain’ suggested:

“The dangers seem to have been over-played...The use of genome edited organisms in farming that lead to reductions in pesticide use could be beneficial”

Others were just pragmatic: *“Interactions are the rule in ecology.”*

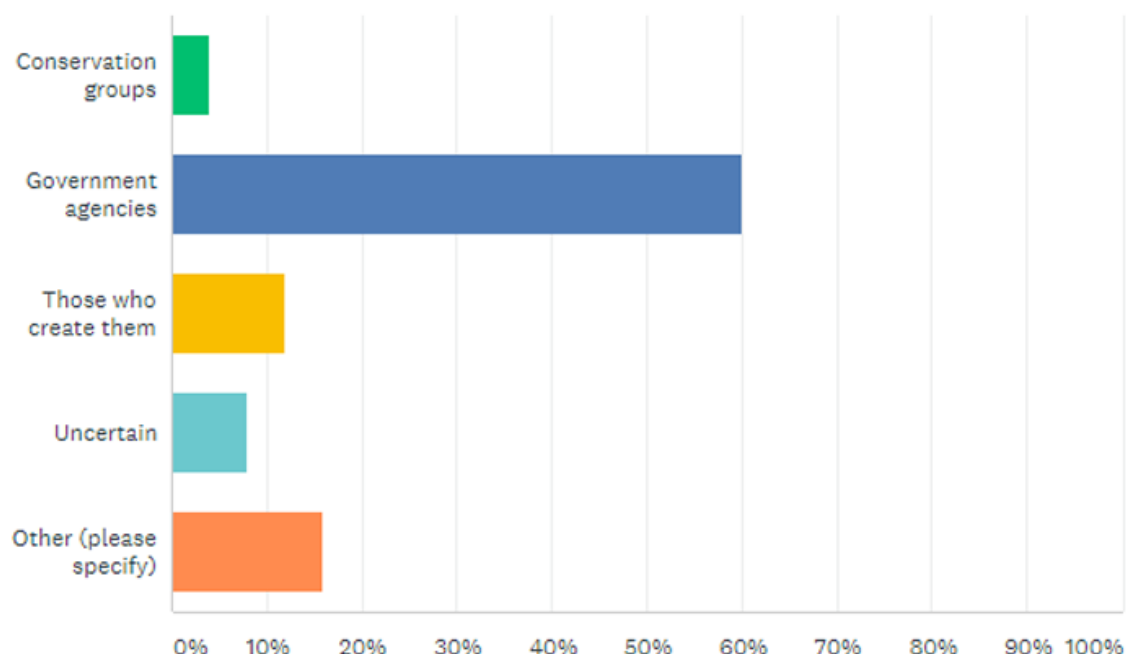
One who indicated support for a moratorium, nevertheless felt: *“The word moratorium is a bit too strong for me.”*

Comparing answers here to those in earlier responses turned up some contradictions. Some respondents who felt that genome editing should be allowed (Q8) stated in this question that there could be potentially harmful interactions between species that have been genome edited for conservation purposes and other living systems (e.g. farming) or that they are uncertain about the effects.

One organisation justified its choice this way:

“The use of these technologies in agriculture is my greatest concern. Any conservation application will be tiny and limited in scope compared with agribusiness. And I fear that these applications will plough ahead regardless of concerns from the conservation sector”

Q14 Who should monitor/assess genome-edited organisms/species in the natural environment for environmental and other impacts?



The majority (60%) agreed that ‘government agencies should monitor/assess genome-edited organisms/species in the natural environment for environmental and other impacts.

The three who stated ‘those who create them’ (12%) were all independent consultants. The four organisations that stated ‘Other’ (14% of the sample population) added other comments specifying the need for ‘independent scientific monitoring’, a mix of all three options, and suggested IUCN, as an independent international scientifically informed body.

One individual respondent who chose ‘government agencies’ added:

“Genome-edited organisms must be monitored independently. That could be through government agencies with an independent scientific mandate; or conservation agencies such as IUCN. I am opposed to them being monitored by commercial interests that cannot act independently”

An individual who selected ‘conservation groups’ commented:

“Governments do not have the resources and those who created them will be biased”

Several added that other stakeholders including citizens should have a role in oversight. One citizen-based organisation suggested that it, and others like it, *“could provide monitoring of impacts where these can be measured by our recorders, either directly or through the use of citizen-deployed passive devices.”*

CONCLUSION

The International Union for Conservation of Nature (IUCN) was due to have an in-depth debate on its position on genome editing during its World Conservation Congress in January 2020. Due to COVID-19 and travel and gathering restrictions this is now rescheduled for an as yet to be determined date in 2021.

This survey nevertheless reveals that both IUCN member organisations (those that actually responded) and other conservation organisations in the UK do not have a detailed or sophisticated understanding of the issue. Some IUCN members did not feel this issue is relevant for them.

Only one explicitly mentioned its support for what it felt was the IUCN's "nuanced" proposal on synthetic biology.

Low levels of engagement

Amongst our respondents only two specialist UK organisations had an official position on the issue. Two European organisations also had positions. The remaining respondents are essentially responding from the position of organisational priorities and norms or their own personal viewpoints. Some of these currently hold very senior positions within UK conservation charities, others are former employees in the conservation sector, academics or practitioners.

The UK organisations both had fairly coherent and detailed critical positions yet did not reject the technology completely. Both expressed clear concern about potential impacts on plants and insect life. One shared its experience of having its concerns dismissed by developers working in the field of genome editing.

However, neither organisation is calling for the technology to be banned. One stated it could still be used in a lab to produce medicines otherwise extracted from plants or animals and the other supports the technology if it is *"Carefully regulated, with proper risk assessment and approval process in place before it is allowed."*

In contrast, the European organisations took a clear official critical position, calling for the technology to be banned. One cited the lack of scientific understanding and few proven benefits, while the other argued that *"protected and setting aside habitats"* are best way forward for species conservation.

Only one respondent, an individual specialising in ornithology, was very enthusiastic about the technology's use in conservation and also supported light touch oversight e.g. industry voluntary codes.

Inconsistencies

The survey exposed inconsistencies in respondents' positions. One senior director at a large conservation charity with international outreach, for example, believed that the technology could be harmful but 'didn't know' whether it should be allowed, banned or subject to a moratorium and felt that 'those who create them' should monitor genome edited species in the environment.

Similarly, another senior researcher working with plants and focusing on 'genomic dynamics and its evolutionary and ecological impact' agreed with the idea of a moratorium while being uncertain of the impacts of the technology, but nevertheless supported voluntary codes and monitoring by 'those who create them'.

Another large UK organisation whose work involves amongst other things, preservation of land and landscape, stated that gene editing was relevant for them now but also ‘didn’t know’ whether it should be banned, allowed or subjected to a moratorium.

A respondent who sits on the IUCN taskforce on synthetic biology, expressed apprehension about how agribusiness will use the technology and that legitimate concerns (about safety, or interactions with the wider environment) will be ignored. He nevertheless felt the technology should be allowed, noting that *“many species are facing extinction for which traditional conservation approaches are not working or cannot work”*.

Taking a wider view of the various surveys our organisation undertook during the first half of 2020, the main differences between the responses to this survey and those of citizens and civil society groups involved in food and farming are:

- Little evidence that most of the respondents here have a detailed knowledge of the technology and the current state of research;
- Far less systemic analysis of the problems arising in conservation and that gene editing may just be a ‘sticking plaster’;
- Greater trust in government and no mention of industry lobbyists;
- Almost no industry language or framings; and
- A much lower level of values-based opposition.

Overall, the concerns of respondents to this survey relate to the poor understanding of the science, the potentially damaging environmental impacts and considering the risks of gene editing against the potential benefits. Respondents were nevertheless clear about the need for strong government regulation – a common thread through all our surveys.

Few organisations took a ‘big picture’ view. Concerns about genome editing tended to be expressed through the lens of individual specialities (e.g. insects, birds, plants).

If there was any group trend at all it was that there was a slight tendency for those working with birds to be more positive about the technology. Given that birds are a keystone species vulnerable to, for instance, habitat destruction, climate variables and exposure to pesticides, this is puzzling. A contrasting general trend in this survey was that those who worked more with insects seemed consistently the most concerned about the impact of genome editing.

COMMENT

While conservation is a worthy goal it is not the only worthwhile goal. What is more, conservation sits within a larger matrix of nature and humanity and involves inevitable compromises. IUCN has been exploring this issue internally and with its members since at least 2016. It is therefore frustrating that for the most part, conservation organisations, even those that are IUCN members, do not seem to be engaging with this issue.

Multiple observers outside of the conservation arena have expressed concerns about the use of genetic engineering, whether it be genome editing or synthetic biology or gene drives, to help achieve conservation goals.

It's true that some arguments for genome editing in conservation seem superficially attractive.

Synthetic biology – creating new man-made species in the lab – is being proposed as a way of saving threatened species like the horseshoe crab whose blood contains a medically valuable molecule that aids the detection of bacterial contamination in medicines and medical devices. As a result, the crab is being harvested to near extinction. A synthetically produced alternative could help conserve these species and the shorebird populations that depend on them.

Gene drives are proposed as a way of neutralising disease carrying insects³ such as mosquitoes. CRISPR, it is proposed, could be used to improve disease immunity in populations of the endangered animals such as the black-footed ferret or to re-engineer bees⁴ to be immune to pesticides. These uses may seem speculative but some are happening now.

In the US researchers are seeking federal clearance to distribute thousands of modified chestnut trees as part of a restoration effort. Regulatory decisions around this could be precedent setting.

Gene drive mosquitoes have been released in part of Brazil, the Cayman Islands, and Malaysia and have been given the go ahead in Florida⁵. There is evidence that they are not performing as expected. The insects were supposed to breed with native mosquitoes and produce weak offspring that would die quickly without passing on their altered genome. Instead, the offspring have proved to be robust⁶ and are now breeding well beyond their original breeding grounds.

Gene drive insects bring with them a whole host of social and ethical issues around individual and community consent, as well as public health and environmental risks. There are also issues around the natural history of disease. Does suppressing one disease, for instance, clear the way for something even more virulent.

A recent briefing⁷ from the Third World Network Biosafety Information Service spotlighted concerns over the bewildering array of GE technologies – including gene drives – that essentially convert the environment into the laboratory, and can affect not only target organisms, but non-target organisms as well. This has implications for all kinds of plants, including crops and perhaps especially organic crops, that could easily be contaminated through inadvertent contact with gene drive 'biomachines'.

³ <https://www.livescience.com/genetically-modified-mosquitoes-create-hybrids.html>

⁴ <https://www.theguardian.com/environment/2018/oct/16/frankenbees-genetically-modified-pollinators-danger-of-building-a-better-bee>

⁵ <https://www.the-scientist.com/news-opinion/750-million-gm-mosquitoes-will-be-released-in-the-florida-keys-67855>

⁶ <https://www.inverse.com/article/59254-genetically-modified-mosquitoes>

⁷ https://biosafety-info.net/wp-content/uploads/2019/11/Biosafety-briefing_From-lab-to-wild.pdf

In fact, we don't know the full extent of how gene drives – which force genetic changes through entire species in the wild – might interact with the natural world.

Research in genome editing plants and animals is more advanced and shows that CRISPR gene editing can cause large scale rearrangements of DNA and unpredictable mutations that can lead to unintended changes in the biochemistry of the organism.⁸

A recent investigation by the Wall Street Journal uncovered unintended effects including enlarged tongues in rabbits and extra vertebrae in pigs bred to be extra meaty⁹. Brazil's plans to breed hornless dairy cattle, gene-edited with TALENs were recently abandoned¹⁰ when a study by the US Food and Drug Administration¹¹ revealed that one of the experimental animals contained a sequence of bacterial DNA including a gene conferring antibiotic resistance.¹²

Will wild animals fare any better? There is no science to guide us on this question, no regulation in place that emphasises testing or monitoring, or makes clear where the responsibility lies if something goes wrong.

In addition, as Beyond GM recently noted, it is impossible to separate nature from activities that take place within the natural world such as agriculture. Opening the door to genome editing with animals opens the door to other uses:

"It is also a relatively short step from re-engineering wild animals to conserve them to re-engineering them for other purposes. Geese, badgers and bison, for example, are all implicated in infecting farm animals with various diseases. What are the potential consequences of genetically 'editing' these wild animals so they don't impact farm animals and therefore farm profits?

Could a genome-edited wild animal unwittingly become a reservoir for zoonotic diseases for which we do not yet have viable treatments? What happens to engineered soil microorganisms when released in the wild? How might they alter the soil structure and microbiome if, for example, genetically engineered organisms become the dominant species?"¹³

These are questions that the lay public, those who are paying members or who donate regularly to conservation causes, would expect conservation organisations, both big and small, to be getting to grips with. To do so may mean breaking out of campaigning silos ("nothing to do with us" "not part of our research brief", "other groups are working on this so we don't have to") and working in closer collaboration with specialist groups already working with genome editing issues.

⁸ <https://genomebiology.biomedcentral.com/articles/10.1186/s13059-018-1458-5>; see also <https://www.gmwatch.org/en/news/latest-news/18593-bound-to-fail-the-flawed-scientific-foundations-of-agricultural-genetic-engineering-part-2>

⁹ <https://www.wsj.com/articles/deformities-alarm-scientists-racing-to-rewrite-animal-dna-11544808779>

¹⁰ <https://www.wired.com/story/brazils-plans-for-gene-edited-cows-got-scrapped-heres-why>

¹¹ <https://www.nature.com/articles/s41587-019-0394-6>

¹² See A Bigger Conversation report Gene Edited Animals in Agriculture <https://abiggerconversation.org/new-report-brings-focus-to-gene-edited-farm-animals>

¹³ <https://beyond-gm.org/gmos-in-conservation-testing-the-fences>